23/C Library MYC

N.A.A.S. QUARTERLY REVIEW

NUMBER

39

Spring 1958

London
Published for the
Ministry of Agriculture, Fisheries & Food
by Her Majesty's Stationery Office

PRICE 2*s*.

COMMONWEALTH MYCOLOGICAL INSTITUTE
- 8 APR 19

AGRICULTURAL RESEARCH COUNCIL

The Diagnosis of Mineral Deficiencies in Plants by Visual Symptoms

(2nd Edition)

A COLOUR ATLAS AND GUIDE

T. WALLACE, C.B.E., M.C., D.Sc., F.R.I.C.

Written primarily for the use of technical officers and advisers concerned with problems of crop production, and for progressive farmers, vegetable growers and fruit growers, this book describes a method of recognising, by sight, deficiency symptoms of the various plant nutrients in commonly grown agricultural and horticultural crops. When the method can be used, it provides the quickest means of determining the causes of failures due to mineral deficiencies and it will often enable a full crop to be harvested where otherwise complete failure might result.

Price 60s.
(61s. 5d., including postage)

Obtainable from
HER MAJESTY'S STATIONERY OFFICE
at the addresses on the reverse of the title page
or through any bookseller

N.A.A.S.
QUARTERLY REVIEW

The Journal of the National Agricultural Advisory Service

NO. 39 SPRING 1958

Contents

ARTICLES

Recent Developments in Agricultural Extension Work in the United States . . . . . *P. V. Kepner* 185
The Early Weaning of Pigs . . . . . *A. F. C. Calder* 194
Nitrification in Soil . . . . . *Jane Meiklejohn* 202
Writing and the Advisory Officer . . . . *H. Edmunds* 208

REVIEWS AND ABSTRACTS

Animal Breeding 212
Aspects of Pig Feeding 213
Dairy Husbandry 216
Herbage 220
Poultry Husbandry 224

REGIONAL NOTE

Farm Circuits and Work Study in Lancashire . *A. H. Fitton* 227

Single copies price 2s. (2s. 4d. by post). Annual Subscription 9s. 4d., including postage. SALE INQUIRIES *should be addressed to the publishers at any of the addresses overleaf.* EDITORIAL COMMUNICATIONS *should be addressed to the Editor, N.A.A.S. Quarterly Review, Ministry of Agriculture, Fisheries and Food, Room 292, Great Westminster House, Horseferry Road, London, S.W.1.*

In the interests of factual reporting, occasional reference in this Review to trade names and proprietary products may be inevitable. No endorsement of named products is intended, nor is any criticism implied of similar products which are not mentioned.

LONDON: HER MAJESTY'S STATIONERY OFFICE

REVIEWS AND ABSTRACTS

In this section of the N.A.A.S. Quarterly Review, it is intended to survey current research and experiment in agriculture, horticulture and the allied sciences applicable to the work of the National Agricultural Advisory Service. It will not be possible, of course, to cover more than a small part of this wide field in each issue.

Responsibility for contributions has been accepted as follows:

Animal Health	A. W. Stableforth, D.Sc., M.R.C.V.S. D.V.S.M.
Animal Breeding	H. P. Donald, D.Sc., Ph.D., F.R.S.E.
Animal Nutrition	S. M. Boden, B.Sc., A.R.I.C.
Bacteriology	J. W. Egdell, B.Sc., N.D.A., N.D.D.
Crop Husbandry	D. H. Robinson, B.Sc., Ph.D., N.D.A.
Dairy Husbandry	A. S. Foot, M.Sc.
Entomology	L. N. Staniland, A.R.C.S., D.I.C.
Farm Management	A. Jones, M.A., B.Sc., B.Litt. L. Napolitan, M.Sc.(Econ.)
Flowers and Soilless Culture	Professor R. H. Stoughton, D.Sc., A.R.C.S.
Fruit	H. B. S. Montgomery, B.A., Ph.D., D.I.C.
Herbage	H. K. Baker, B.Sc., Ph.D., Dip. Ag.
Horticulture	C. E. Hudson, C.B.E., N.D.H., V.M.H.
Machinery	C. Culpin, M.A., Dip. Agric., M.I.B.A.E.
Mycology	H. E. Croxall, B.Sc., Ph.D.
Plant Breeding	J. L. Fyfe, M.Sc.
Poultry Husbandry	R. Coles, M.Sc.Agric., M.Sc.(Econ.), B.A., Ph.D.
Soils	W. Morley Davies, M.A., B.Sc., F.R.I.C., Dip. Agric.
Virology	K. M. Smith, C.B.E., Ph.D., D.Sc., F.R.S.

© *Crown Copyright 1958*

Published by
HER MAJESTY'S STATIONERY OFFICE
To be purchased from

York House, Kingsway, London w.c.2 — 423 Oxford Street, London w.1
13a Castle Street, Edinburgh 2 — 109 St. Mary Street, Cardiff
39 King Street, Manchester 2 — Tower Lane, Bristol 1
2 Edmund Street, Birmingham 3 — 80 Chichester Street, Belfast
or from any bookseller

Recent Developments in Agricultural Extension Work in the United States

P. V. KEPNER

Deputy Administrator, Federal Extension Service, United States Department of Agriculture

DURING RECENT YEARS there has developed within the ranks of our rural people and their organization leaders, and also within the leadership of the Department of Agriculture, a resurgence of conviction that research and education are the foundation stones of progress. This is true with respect to agricultural progress and the progress of our farm people, as it is with respect to all other segments of our economic and social structure.

This in no sense implies that other programmes administered by our Department of Agriculture are not important. They have their place and are making definite contributions.

Rather, it is to say that undergirding all of these—adequate and appropriate research, and an adequate and efficient means of getting the results of such research understood and used by those who can profit from such use—is most essential to satisfactory progress.

Increases in Funds and Personnel

Out of this conviction we have had increasing public support for research and extension work during these past few years.

For example, during the last five fiscal years total extension funds available to the States and counties have increased over 50 per cent from $84,705,000 to $128,000,000. About 42 per cent of this increase has come from Federal appropriations and 58 per cent from State and county appropriations. The State and county increase of approximately $8,000,000 for fiscal year 1958 is the largest yearly increase from that source in the history of the Co-operative Extension Service.

The number of professional extension workers in the States and counties have not increased by the same percentage. Increasing salary levels and operating costs have not made that possible. However, from June 30, 1953 to April 30, 1957, the number of such workers has increased from approximately 12,600 in the States and counties to slightly over 14,000. Of these 10,845 are county workers. These figures do not include non-professional workers such as secretaries. The professional staff of the Federal Extension Service increased during this period from 70 to 106.

More Intensive Farm and Home Counselling

Those aggressively supporting increased funds in support of extension work have rather definite ideas as to why such additional resources are essential.

They recognize that the demands upon our extension workers have become so great that current staffs are entirely inadequate—that they are faced with so many demands they cannot give adequate time and attention to individual farm families as they did in the early days of extension work. They also are quite aware of the fact that the growing complexity of current-day agriculture in the United States—from both the economic and technical aspects—makes the problems of farm families much more complex and therefore necessitates more intensive extension assistance.

These facts also are well recognized by all professional extension leaders. Hence the first emphasis on the use of increasing extension resources was placed on two fronts with identical purposes. These were to add county workers—both men and women—*who would concentrate on advising with a limited number of farm families*, 50 *to* 100, with respect to their total complex of farm and home management problems. The other was to insure that as many county extension workers as possible find time in their general extension programme efforts to render the same type of intensive advisory assistance to a few farm families.

This effort on the part of our Extension Service to provide farm families, in a better organized and more intensive way, with necessary counsel and assistance is to enable these families to:

(*a*) identify and analyse effectively all their major farm and home situations and opportunities;

(*b*) determine a definite course of action in relation thereto which will produce the maximum in terms of continuing economic returns and family satisfactions;

(*c*) put such plans into effect as rapidly as practicable; and

(*d*) adjust them wisely as circumstances warrant in light of changing conditions and all the pertinent research information available.

The objectives of this work, as far as the individual family is concerned, are to help the family improve *its analysis and decision-making ability;* to choose a course of action best suited to its needs, desires, and resources; and to carry out this course of action in an efficient and orderly manner. We do not look upon such families as demonstration families and we do not make decisions for them.

The "new" aspects of this work by our Service are the fact that we undertake getting the farm family to analyse their entire complex of interests—both farm and home—and the fact that we have a concentrated effort to expand this intensive type of counselling work despite the extremely heavy demands upon the staff.

This shift in emphasis does not in any sense mean an abandonment

of Extension's other time-proven methods of reaching farm families, or of helping them with respect to particular economic or technical problems. These must be continued—necessity and practical considerations demand it. But it does mean a conscious and gradual shifting of emphasis toward providing a more complete educational service to individual farm families more in keeping with the complexity of problems facing them under modern-day farming conditions.

The reaction of farm people to this work has been most enthusiastic. Improvements which individual families have been able to make as a result of such counselling, in many instances, have been almost dramatic. Many individual cases have been reported rather widely by the rural press and radio. As a result the demand is on the increase.

This presents the problem of providing an adequate and adequately trained staff to meet the demands. This problem will likely be with us for some time.

Problem versus Speciality Approach

Closely related to the renewed emphasis on the unit approach in individual farm family counselling is the rapidly growing tendency on the part of extension workers to pool their competencies on a problem basis rather than operate on an individual speciality basis. Many problems facing farm people require the application of many separate elements of technology.

For instance, our Food and Drug Administration recently narrowed the tolerances of obnoxious foreign materials which would be permitted in wheat marketed for human consumption. Introduction of such foreign materials into the grain could occur all the way from the harvest field to the final processing plant. Adequate control measures involve the competencies of the agronomist, the engineer, the entomologist, the rodent control specialist, and others. Each could attack this problem independently—and in times past did just that. This left the individual farmer with the responsibility of sifting out from the several recommendations from these various sources those practices which he thought would accomplish the greatest results. Some were successful in this effort. Many others were not. Organizing these various specialists' efforts more effectively and co-ordinating them was a problem for extension leaders.

Recognizing this need, both in the interest of farmers and greater efficiency within the Service itself, resort has been taken to establishing working groups or *task forces* of the various specialists having a direct contribution to make to the solution of a given problem.

In connection with this particular problem we organized a group of specialists on the Federal Extension Service staff into a task force to develop a co-ordinated programme of assistance to the States. This task force was chaired by the member of the Administrator's immediate staff giving leadership in the programme field. They developed a

suggested programme of educational action to be recommended to the States concerned, with all of the appropriate scientific practices incorporated. They developed supporting educational materials for use by the States. Each member of this group, whether an agronomist, engineer, entomologist, or information specialist, was then in a position to counsel with individual State extension service workers on all points of the total programme.

States concerned established similar committees to adapt and add to the suggestions from our Federal committee and plan a course of action within their respective States. The State programmes involved working with farmers to get them to understand the necessary precautions and control measures to be employed on the farm, both in harvesting and storing wheat. They also involved working with the handlers of wheat all the way from the local elevator operator to the miller.

In other words, a complete package programme, involving coverage of all necessary precautionary and control measures, was developed, outlined simply and worked at collectively by all who had a contribution to make, irrespective of their particular technical training and proficiency.

This may not sound new in principle, and it is not. The new aspect is simply a greater appreciation that the maximum productivity from our extension specialist resources cannot be gained through their functioning independently. As a result we have had quite a widespread development in co-ordinating the efforts of our technical resource people on a problem basis with most gratifying results.

Increased Responsibility with respect to Other Government Programmes in Agriculture

Since 1953, the responsibilities of the Extension Service for educational work associated with other programmes of the Department of Agriculture have been officially recognized and stipulated by the Secretary of Agriculture. He has charged the Federal Extension Service of the Department with the educational leadership responsibility for all Department programmes.

This charge does not include efforts to "sell" to farmers the programmes of other agencies. Rather it is directed toward ensuring that all farmers know that such programmes are available, what they are intended to accomplish, and where farmers can obtain such assistance as these other programmes have to offer. The most important responsibility vested in the Extension Service in this regard is that of helping farmers to appraise these programmes in terms of how they can be most effectively used, when applicable, to improve the individual farm family's welfare.

Modernizing State Extension Service Organizations

In its nearly 50 years of functioning as a formally organized public service the growth of our Extension Service has been fairly gradual until the past few years. As a result there has been a tendency to perpetuate the organizational pattern established in the early years. Within the past few years there has been both a significant increase in the size of staff in the average State and a greater complexity of problems with which to deal. This has created a recognition of the need to examine closely the prevailing organizational and functional patterns within the State services in the interest of maximum feasible efficiency and productivity.

In a few States the governing bodies of the universities involved have employed commercial management firms to analyse their organizations, including their extension services, and to recommend adjustments. In other States the Federal Extension Service, in co-operation with the State extension services themselves, are making similar analyses and developing recommendations for improvement. In these instances a committee comprised of representatives of our Administrator's immediate office and representatives of our Management Operations Division work with a comparable committee of the State extension staff. They jointly plan the analysis phase of the study and then, through a series of meetings over several months, develop recommended adjustments. In our co-operative system the final determination of adjustments to be put into effect and the timing of them is the responsibility of the State.

Without going into details may I point to a few generalizations that appear to be fairly common in these separate studies:

(*a*) State extension directors do not have enough top-level assistants to cope adequately with the rapidly growing administrative programme and public relations responsibilities.

(*b*) An inadequacy of supervisory assistance from the State headquarters to assist county staffs in the all important business of developing and conducting timely, pointed, and most effective educational programmes.

(*c*) An inadequacy of planned services in the personnel field—systematic and forward-looking recruiting programmes, organized induction and in-service training programmes for county staff, and related matters.

Other items could be cited, but the above reflect the general nature of some of the adjustments that need to be made better to enable the State extension services to cope effectively with their growing responsibilities. We are glad to report that several States have already made major adjustments in their organizational and administrative patterns. These are serving as demonstrations to others and several more are in process. We expect this trend to continue actively over the next few years.

Increased Emphasis on Staff Training

The situation outlined just previously emphasizes the fact that there is a great need for prospective and most current extension administrators to have an opportunity for formal training in the field of administration. Recognizing this need, the Extension Section of the American Association of Land-Grant Colleges and State Universities undertook to enlist the assistance of a Foundation to establish a training centre in extension administration. This objective was attained in 1955 and such a centre, designated the National Agricultural Extension Centre for Advanced Study, was established at the University of Wisconsin, at Madison, Wisconsin.

This centre is conducting, in collaboration with other divisions of the University's Graduate School, formal training work in extension administration at both the master's and doctorate level. Currently there are 32 graduate students enrolled in this work from the staffs of different State Extension services. It provides scholarships for prospective extension administrators nominated by the various State extension directors from their current staffs. It conducts short courses and workshops for current extension administrators. It is also just getting under way a research programme in the field of extension administration.

We feel this is a very significant development promising real progress in training extension administrators for more efficient service.

Another organized training effort is that of the National Project in Agricultural Communications—also supported by a Foundation grant at the request of the Extension Section of the Association. This project is dedicated to both research and training in the field of more effective communications. It has developed two units of training materials covering the fundamentals of effective communications and oral communications. By the end of this summer, five workshops of three weeks' duration, for teams of four extension workers from each State and the Federal Extension Service, will have been held.

These trainees in turn conduct similar training experiences for State and county extension workers. This training experience has been most enthusiastically received by all those who have had an opportunity to participate in it.

In addition to the basic principles and oral units, which have been completed, training units in the specific fields of written communications and visual communications, with a comparable series of training workshops on each, are contemplated.

The number of special State staff members assigned responsibility for developing and carrying out staff training programmes increased from 11 in 1953 to 33 in 1956. There are now such special workers in 30 of our States. We anticipate this trend will continue.

Paralleling this development there were 30 States in which the State colleges were offering undergraduate credit courses in extension

education. Enrolment in these courses totalled 1,586—a gain of about one-fifth over 1953.

Over 2,000—roughly one-seventh of the total staff, were participants in organized training experiences during 1956 other than regular college course work. These experiences included college-organized workshops, regional summer schools, and special subject-matter refresher courses. *These were in addition to very short-term* (usually two or three days) *conferences* of county extension workers in practically all States during which some training work is normally involved.

During this same period, two additional colleges or universities have inaugurated formal curricula in extension education at the graduate level. There are now 11 institutions offering graduate degree work in extension education and 36 States which provide part-time salary for extension workers on study leave. Two of these 11 institutions are now offering doctorate degrees in this field.

Experimentation and Evaluation

Reference has been made to the intensification of extension's advisory services to individual farm families. In that connection a question logically can be raised as to the degree of intensity which would be justifiable.

To help provide evidence on that front, an experimental educational programme has been launched in the State of Michigan. Five representative townships were chosen in different sections of the State. A full-time extension worker was employed to work solely in each of these townships. The number of farm families in each varied from 70 to 180. Regular calls are made by the township agent to each of the farm families and an intensive counselling service rendered. This programme was set up to operate for a period of five years, with just about half of that period having already expired.

No final conclusions can be drawn from this experiment as yet. However, evidence to date indicates that the programme is being received very wholesomely by the families concerned. They feel the regular visits of the township agent and the frequent opportunities to counsel with him are most helpful. As measured by increase in net farm incomes obtained by these families up to the present time, despite an opposite trend on the part of other farmers in the same general area, justification can be found for this enthusiasm.

In four States (New York, North Carolina, Iowa and Washington) five-year evaluation projects of the more intensive farm family counselling work have been inaugurated in co-operation with the respective State experiment stations. The objectives of these studies are (*a*) to determine the relative effectiveness of the intensive farm and home unit approach in extension as compared with the more extensive methods now in use, and (*b*) to analyse the results obtained from the somewhat different methods being used in each of these States. We

anticipate that the composite of this work will provide worth-while guide posts for extension in succeeding years.

Another question all of us have with respect to this intensive type of counselling service is the percentage of our farm families who would be interested in and desirous of such services. One of the above States, as a part of its research project, has undertaken to discover some clues, at least, to the answer to this question. Their preliminary findings indicate that in the area of this study there were 36 per cent of the total families studied who would be interested and 36 per cent at the other end of the scale who probably would not be interested. The remaining 28 per cent indicated they probably would be or might be interested.

When we recognize that our farmers do have access to all phases of our general extension activities, plus a constantly increasing number of other sources of technical information, these tentative data become quite revealing. Possibly after the more intensive counselling work becomes better understood these percentages may change significantly. Further exploration of such questions is sorely needed.

Another special research study recently inaugurated is one directed to ascertaining through research the public interest in and desire for popular publications on subjects or problems in the fields of agriculture and home economics. The Department of Agriculture and the State Land-Grant Colleges are distributing over 30,000,000 copies of such publications each year. However, the determination as to the subject matter or problem areas to be treated in such publications is made largely by the various scientists in research or extension.

The question has been raised as to the validity of this process of determining publication subjects. Hence, the Federal Extension Service, the Agricultural Research Service and the Office of Information, all of the Department of Agriculture, are collaborating with the land-grant colleges in such a research undertaking. It is hoped that out of this process we can get better guidance as to the type of publications the public desires and will use most effectively.

Other research work under way is directed to such matters as comparative values of different extension methods used in comparable situations, effectiveness of different types of training of local leaders, and many other facets of extension operations. Research work in this general area has expanded some since 1953 but not as rapidly as we would desire. The primary limiting factor is the limited availability of trained research personnel who can be employed for this important work.

Summary

Extension resources and staff in the United States have expanded markedly during the past four years. A major use of these additional

resources has been to expand the intensive farm and home unit counselling work in order to render an educational service more nearly adequate to the needs arising from a rapidly changing and more complex farm economy.

Efforts to co-ordinate the proficiencies of our various technical specialists into a problem approach rather than the older "specialist" approach have been expanding significantly. Marked progress in rendering a more practical service and in ensuring more efficient use of such specialist competence is noted.

The contributions which local extension workers can make in helping farm people individually make more effective use of other agencies' programmes and services have been recognized and contributions expanded on this front.

State extension service organizations are being analysed and remodelled to make them more efficient and more adequate to current-day demands.

Significant progress has been made in increasing in-service and graduate training opportunities for extension workers. Also, significant advancements have been made in testing out new approaches in extension work and in evaluating our operational procedures to discover ways in which greater contributions can be made and greater efficiencies created.

These, we feel, are some of the major advancements made during the past few years. We recognize that much more must be done in the years ahead.

ACKNOWLEDGMENT

This article is based on the Paper presented by Mr. Kepner to the International Working Conference of Directors and Senior Officers of Agricultural Advisory Services held in June, 1957, under the auspices of the European Productivity Agency of the Organization for European Economic Co-operation. Grateful acknowledgment is made to the author and to the Head of the Division for Productivity in Food and Agriculture for their permission to publish.

The Early Weaning of Pigs

A. F. C. CALDER

The Rowett Research Institute, Bucksburn, Aberdeenshire

THE TRADITIONAL METHOD of rearing pigs is to allow the sow to suckle them for a period of eight weeks, during which time they should have become accustomed to eating solid food fed either in pellet form or as a dry meal. This system is usually referred to as "natural rearing".

The choice of eight weeks as a weaning age for pigs is purely arbitrary and probably originated because at one time this was the minimum age at which the average piglet was heavy enough, that is, sufficiently well developed physiologically, to be weaned on to a conventional pig meal; and it was the maximum age which allowed the sow to farrow and wean two litters within a year. Over the past twenty to thirty years the average weaning weight of naturally reared pigs has increased from about 28 to about 35 lb, largely due to the widespread adoption of creep feeding, and it therefore follows that piglets may now be weaned at earlier ages than eight weeks without recourse to any special diets or techniques. "Early weaning" generally implies weaning at weights under 25 lb.

Advantages of Early Weaning

Early weaning has been credited with many advantages over the natural rearing method, but it is essential when assessing these to differentiate between weaning soon after birth on to a liquid sow's milk substitute food and weaning at 10 or more days of age on to dry meal diets. The principal difference is that the latter is simpler and more successful in practice. Of the many advantages claimed for early weaning only two are of any real importance. The first, applicable to weaning at any age under 14 days, is the 25 per cent increase in number of litters (five litters every two years) obtained per sow, and the second, applicable only to weaning at birth, is the prevention of the considerable loss of young pigs, about 20 per cent on average, which occurs in the first few days of life.

There is a third possible advantage: all the piglets of an eight-week-old litter may be more even in weight because the effect of variation in milk yield between teats has been eliminated and they will all have been given an equal chance. However, this is not always assured unless the litters are weaned at a very early age, since the development of runts and undersized pigs seems to occur within the first seven days of life.

The possible advantages of weaning piglets soon after birth are therefore very great but so, unfortunately, are the disadvantages. If the piglets have received no colostrum because they have been removed at birth for reasons such as the death of the sow or her inability to suckle, then rearing the piglets is virtually impossible except under germ-free laboratory conditions [1, 2, 3, 4, 5, 6, 7 and 8].

Disadvantages

It is possible to rear piglets away from the sow if they have received colostrum for a minimum of 24 hours, but it is generally impracticable since the diets they require are very expensive and the conditions of hygiene, environment and management must be very strict. Artificial rearing of a few pigs surplus to the number of teats from soon after birth is neither practicable nor economical as a routine farming practice. It can only be regarded as of value when the entire litter has to be reared artificially. Successful liquid diets for weaning at a few hours old have been formulated [9, 10, 11 and 12], but many of the ingredients are difficult to obtain and it would be impracticable for the farmer to attempt to mix them himself. It is more convenient to purchase one of the commercial sow milk substitutes now on the market.

Because of the many difficulties, the development of weaning very young pigs on to liquid diets as a routine farming practice has been almost abandoned, and research workers and manufacturers have concentrated on developing the technique of weaning on to dry meal diets at the earliest and most profitable age.

Age and Weight at Weaning

At present there is very little information on the performance of pigs weaned at different weights. In a recent experiment at the Rowett Institute [13], the eight-week weights of piglets weaned at 8, 14 and 20 lb respectively, tended to favour those weaned at 14 lb. As one of the main advantages of early weaning depends upon the rapid remating of the sow to produce five litters every two years, it follows that the piglets have to be weaned sufficiently early to make this possible. In practice, there is no advantage in weaning before 14 days of age when they weigh 8-10 lb since 15-20 days after farrowing is the earliest that it is possible to effectively re-mate the sow. A delay of 14 days instead of the often recommended one of 10 days means heavier pigs which are less likely to suffer such a marked check in growth rate as those weaned earlier. Also, since a more complex and expensive diet is fed up to 25 lb live weight than later, the heavier the piglets are at weaning, the less they will eat of the more expensive diet. On the information at present available it seems reasonable to assume that within the limitations imposed by having five litters produced per sow every two years, weight and vigour are more important than age in the selection of pigs for early weaning.

Re-mating the Sow

So far as is known, no detrimental effects on health have been experienced by removing the sow from the litter 10-14 days after farrowing provided that care is taken with her rationing. Although she is approaching peak milk yield at this time, drying her off need present no difficulties provided that overfeeding is avoided. Sows kept on an

early weaning system should not be given more food after farrowing than they were receiving before, otherwise there may be re-mating difficulties due to the sows becoming over-fat. More information is required, however, on the effects of weaning at different ages on the sow's subsequent reproductive performance.

Management

Early weaning at ages from 10 to 21 days has now been adopted as a routine practice on many farms with varying degrees of success. In general, the system has been found easy to operate, provided conditions of housing and management are reasonably good. Systems vary, but the one adopted at the Rowett Institute may be regarded as typical. Piglets are weaned at about 8-10 lb at 10-14 days of age and the males are castrated immediately. They are then placed in a pen or hut, which must be warm, dry and free from draughts. A small amount of meal is provided in a shallow trough or tray and, together with clean, fresh drinking water, should be available at all times. It is not necessary to rub the piglets noses in the meal or use any other stratagems to encourage the piglets to start eating. After a few hours, the piglets become interested and start taking small amounts of the meal. There is an initial check period following weaning lasting from 3 to 15 days, during which time the piglets appear to lose condition. However, they soon start to eat increasing amounts of the meal and growth then becomes rapid. As the piglets are fed *ad lib.*, they tend to overeat and this commonly leads to scouring during the early stages of growth. This may be overcome by withholding food, but not water, for a period of 12-24 hours.

Housing

From 8 to 25 lb is the most critical period in the life of piglets, and growth rate during this stage depends to a large extent on their ability to adapt themselves to a sudden and changed environment. Most authorities consider that the air temperature within the rearing house should not be allowed to fall below 60-65°F, and that some form of heat should be provided close to the piglets. This can be achieved by efficient insulation and ventilation and the provision of a dry, draught-proof bed. Infra-red lamps have been found useful in providing a concentrated heat immediately over the pigs. Many old buildings have been successfully adapted for the purposes of early weaning without undue expense.

Diets for Young Pigs

The problem of formulating diets for early weaned pigs is complicated by the fact that there is considerable variation between published estimates of the nutritional requirements of piglets at different weights and ages who have been fed different types of rations. Satisfactory diets for use in early weaning have been formulated, however, but they are

very expensive since they contain considerable proportions of such commodities as skimmed milk powder and glucose. The mineral mixtures incorporated are also very complex. Alternative sources of nutrients and, if possible, a simpler and less expensive mineral mixture are very desirable if artificial rearing is to remain an economic proposition. Unfortunately, the search for alternatives has not been very successful

CARBOHYDRATES

Data from experiments with 10-day-old pigs at the Rowett Institute [14] suggest that sucrose is superior to starch presumably because of higher digestibility. For pigs less than seven days old, however, glucose gives much better results than sucrose [18]. In American experiments [19] 2-day-old pigs on a diet containing sucrose developed severe diarrhoea and many died, but those that survived to 7 days of age were showing some ability to utilize it. In our experiments, 7-day-old pigs have tolerated 10 per cent sucrose in the diet without ill effect, and indeed showed significant improvements of 8 per cent in growth rate and 10 per cent in food conversion efficiency. The relative value of different carbohydrates for the 7 to 10-day-old pig has been summarized by Hudman *et al.* [20] who obtained liveweight increases between 1 and 5 weeks of 10.6, 8.6, 8.3, 6.9 and 6.9 lb using purified diets containing lactose, sucrose, glucose, maize starch and oat groats respectively. In this respect, the recent reports by Canadian workers [22 and 23], on studies of the digestive system in young pigs is of interest. Briefly, these findings indicate that the lack of enzymic activity in the digestive system of the young pig may be responsible for its inability to utilize a wide range of nutrients at an early age, and would explain the reported differences in the values of various carbohydrates for pigs at different ages. Of the carbohydrate-splitting enzymes, only lactase would appear to be fully active during the first week of life, and therefore it follows that lactose (milk sugar) is the most suitable carbohydrate for inclusion in liquid diets for very young pigs. After 10 days of age, amylase, sucrase and maltase became increasingly active and so starch, sucrose (cane sugar) and maltose may be included in greater amounts in the diet.

FAT

In our experiments, adding fat to dry meal mixtures to give 7 per cent fat in the diet of 10-day-old pigs tended to improve food conversion efficiency and, to a lesser degree their growth rate [14]. Canadian workers [15] found that the addition of 10 per cent oil to give 13 per cent crude fat in the diet improved growth rate, but that the diets were too oily and sticky for use in practice. We find that the inclusion of 2 per cent oil improves the consistency of the dusty meal mixture.

PROTEIN

The usual source of protein in synthetic diets has been casein or skimmed milk powder. Fishmeal has been tried without much success as an alternative source for 2-day-old pigs, but in a recent experiment at the Rowett Institute with pigs weaned at 10 days, dried skimmed milk has been replaced in part and in whole by fishmeal without affecting growth rate or food conversion efficiency. Experiments to date have given very variable results regarding the optimum percentage of protein in the ration [11, 14, 15, 16 and 17]. At this Institute, food conversion efficiency was significantly improved by 10 per cent when the crude protein in the diet was raised from 24 to 29 per cent in the diet of pigs weaned at 10 days old. Increasing the protein to 34 or 39 per cent brought no further improvements and there were no significant differences in growth rate attributable to protein level. A level of 30 per cent has been giving satisfactory results in practice.

Enzymes similarly must play a significant role in the utilization of protein. Protein-splitting enzymes appear to be present in the stomachs of young pigs [24], but remain inactive until the pH of the stomach falls below a level not normally reached until 20-30 days of age. Dried skim milk is a valuable food for young pigs because it contains readily digestible carbohydrate and protein, but it is a very expensive food in this country at the present time. If the piglet's ability to digest various nutrients could be improved by supplying the necessary enzymes, a wider range of cheaper ingredients for diets would become available. This is the theory behind the inclusion of specific enzymes in baby pig diets, but so far little success has been achieved. Some American workers [25] have reported improvements in the performance of young piglets from the inclusion of pepsin in the diet but others have failed to confirm this. More research is necessary before any recommendation can be made about the inclusion of enzymes in early weaning diets, and it is doubtful whether the complex digestive processes can be speeded up so simply as some imagine.

MINERALS AND VITAMINS

Little is known of the specific requirements of young pigs for these substances, but many supplements are based on the amounts present in sows' milk or found adequate for rats. The tendency has been to include levels sufficient to provide a wide margin of safety, but these generous amounts of complex mineral and vitamin supplements, many of which may be surplus to requirements add to the cost of the diet, and may produce interactions which may render one or more nutrients less effective. Quantitative details of the supplements used in baby pig rations at the Rowett Institute will be found in Tables 2 and 3 on page 200.

ANTIBIOTICS

Dry meal diets for early weaned pigs have invariably contained an antibiotic as an insurance against many of the hazards to which piglets are exposed during their early life. Various levels have been used in the diets ranging from 18 to 112 mg/lb [14, 15, 21, 26 and 27], and in most instances the higher levels have produced better results than the lower. No experiment has yet been reported comparing diets with and without an antibiotic, and this makes the choice of any one level difficult. It may be that the response obtained from the high levels of antibiotic may not justify the extra cost of including them in the diet. The evidence at present, however, suggests that some antibiotic in the diet may be of use in reducing the incidence of diseases which give rise to scouring.

Summary

Under farm conditions it is very difficult, if not impossible, to rear pigs which have not suckled their dam for at least 24 hours so as to obtain sufficient colostrum. Two-to-ten-day-old pigs can be reared, but only under the best of conditions of feeding, housing and management. Suitable diets for this purpose are available but expensive and at present should be used in emergencies only, *e.g.*, the death of a sow or absence of milk immediately after farrowing. On the other hand, pigs over 10 days of age can be reared successfully and their 8-week weights should be equal to, and in most cases surpass, those of naturally reared pigs. Diets for weaning at this age are less expensive but still costly enough to make early weaning of doubtful economic value at the present time. In addition, the long-term effects of early weaning on the reproductive performance of the sow and on carcass quality at bacon weight will have to be investigated before a general recommendation for adopting the system can be given.

Table 1

Example of a Diet for Pigs Weaned at 2 Days Old*

	per cent
Casein	13
Sucrose	39
Maize starch	25
Dried whole milk	15
Yeast	5
Trace mineral mix.	3

Plus 7,200 i.u. vitamin A, 1,800 i.u. vitamin D, 250 mg alpha tocopherol acetate and 14 mg penicillin per lb of diet.

*McRea and Tribe. Vet. Rec., 1956, 68, 741

Table 2

Example of a Diet for Pigs Weaned at 10 Days Old*

	per cent
Dried skim milk	42
White fish meal	15
Dried yeast (75% unext.)	5
Rolled oat groats	24
Sucrose	10
Cod liver oil	2
Salt (NaCl)	0.5
Trace mineral mix.	1.0
Antibiotic	0.5

1 lb mineral supplement contains $MgSO_4.7H_2O$, 22.9 g; $FeSO_4.7H_2O$, 18.1 g; $CuSO_4.5H_2O$, 2.67 g; $MnSO_4.4H_2O$, 7.40 g; $ZnSO_4.7H_2O$, 1.97 g; KIO_3, 0.076 g; $CoSO_4.7H_2O$, 0.428 g; maize starch, 200 g; ground flaked maize, 200 g.

*Smith and Lucas—Unpublished data.

Table 3

Example of a Diet for Pigs at 5 Weeks Old*

	per cent
Dried skim milk	3
White fish meal	10
Rolled oat groats	45
Ground barley	30
Fine white thirds	10
Salt (NaCl)	0.5
Trace mineral mix.	1.0
Antibiotic	0.5

Plus: 1 mg riboflavin and 1 mg calcium pantothenate per lb of diet, added in maize starch.

1 lb mineral supplement contains $MgSO_4.7H_2O$, 22.9 g; $FeSO_4.7H_2O$, 18.1 g; $CuSO_4.5H_2O$, 2.67 g; $MnSO_4.4H_2O$, 7.40 g; $ZnSO_4.7H_2O$, 1.97 g; KIO_3, 0.076 g; $CoSO_4.7H_2O$, 0.428 g; maize starch, 200 g; ground flaked maize, 200 g.

*Smith and Lucas—Unpublished data.

References

1. S. Dyrendahl, O. Swahn, G. Bjorck and L. Hellving. *Acta. Agric. Scand.*, 1953, **3,** 334.
2. G. A. Young and N. R. Underdahl. *Cornell Vet.*, 1949, **39,** 120.
3. G. A. Young and N. R. Underdahl. *J. Immunol.*, 1950, **65,** 369.
4. L. K. Bustad, W. E. Ham and T. J. Cunha. *J. Anim. Sci.*, 1947, **6,** 484 (Abst.).
5. L. K. Bustad, W. E. Ham and T. J. Cunha. *Arch. Biochem.*, 1948, **17,** 249.
6. B. C. Johnson, M. F. James and J. L. Krider. *J. Anim. Sci.*, 1948, **7,** 486.
7. B. E. Sheffy, C. A. Gallecos, R. H. Grummer, P. H. Phillips and G. Bohstedt. *J. Anim. Sci.*, 1951, **10,** 867.
8. D. V. Catron, L. F. Nelson, G. C. Ashton and H. M. Maddock. *J. Anim. Sci.*, 1953, **12,** 62.
9. A. L. Neumann, J. B. Thiersch, J. L. Krider, M. F. James and B. C. Johnson. *J. Anim. Sci.*, 1950, **9,** 83.
10. R. C. Wahlstrom, E. M. Cohn, S. W. Terrill and B. C. Johnson. *J. Anim. Sci.*, 1952, **11,** 449.

11. M. R. McCrea and D. E. Tribe. *Vet. Rec.*, 1956, **68**, 741.
12. J. A. Weybrew, H. A. Stewart, G. Matrone and W. J. Peterson. *J. Anim. Sci.*, 1949, **8**, 207.
13. H. Smith and I. A. M. Lucas. *J. Agric. Sci.*, 1957, **49**, 405.
14. H. Smith and I. A. M. Lucas. *J. Agric. Sci.*, 1956, **48**, 220.
15. E. W. Crampton and O. M. Ness. *J. Anim. Sci.*, 1954, **13**, 357.
16. R. F. Sewell, B. E. Sheffy, R. G. Eggert and J. K. Looslie. *J. Anim. Sci.*, 1953, **12**, 597.
17. D. E. Becker, D. E. Ullrey and S. W. Terrill. *J. Anim. Sci.*, 1954, **13**, 346.
18. S. R. Johnson. *Fed. Proc.*, 1949, **8**, 387 (Abst.).
19. D. E. Becker, D. E. Ullrey and S. W. Terrill. *Arch. Biochem.*, 1954, **48**, 178.
20. D. B. Hudman, V. C. Speer, G. C. Ashton and D. V. Catron. *J. Anim. Sci.*, 1955, **14**, 1209 (Abst.).
21. F. Diaz, V. C. Speer, G. C. Ashton, C. H. Liu and D. V. Catron. *J. Anim. Sci.*, 1956, **15**, 315.
22. C. B. Bailey, W. D. Kitts and A. J. Wood. *Canad. J. Agric. Sci.*, 1956, **36**, 51.
23. W. D. Kitts, C. B. Bailey and A. J. Wood. *Canad. J. Agric. Sci.*, 1956, **36**, 45.
24. A. V. Kvasnitskie and E. N. Bakeeva. *Trud. Inst. Svinovod, Kiev*, 1940, **15**, 3. (Abst. in *Vet. Bull.* **13**, 222, 1943).
25. R. O. Baker, C. J. Lewis, R. W. Wilbur, P. A. Hartman, V. C. Speer, G. C. Ashton and D. V. Catron. *J. Anim. Sci.*, 1956, **15**, 1245.
26. C. J. Lewis, D. V. Catron, C. H. Liu, V. C. Speer and G. C. Ashton. *J. Agric. Fd. Chem.*, 1955, **3**, 1047.
27. C. J. Lewis, D. V. Catron, G. E. Combs, G. C. Ashton and G. C. Culbertson. *J. Anim. Sci.*, 1955, **14**, 1103.

Nitrification in Soil

JANE MEIKLEJOHN

Soil Microbiology Dept., Rothamsted Experimental Station, Harpenden

NITRIFICATION is the last stage of the so-called mineralization of nitrogen, in which insoluble forms of this essential element are transformed into soluble forms which plants can readily assimilate. It is therefore an extremely important soil process, though, unlike nitrogen fixation, it does not add to the total amount of nitrogen in a soil.

Sources of Ammonia

As nitrate is formed, in the nitrification process, by the oxidation of ammonia in two stages, the formation of ammonia must always precede the formation of nitrate. The sources of ammonia in soil are probably threefold. The first source is the best-known; the breakdown of proteins in decaying organic matter. A large number of microbial species of different kinds take part in this process, both in the initial stages, when the complex proteins are broken down to peptides and amino-acids, and also in the final stage, when ammonia itself is formed. Another less well-known source of ammonia is chitin, the stiffening substance in the skins of insects and other arthropods (woodlice, spiders, mites, *etc.*). Chitin also makes the walls of fungus threads (mycelium). As small insects and mites, and also fungi, are very numerous in soil, the amount of chitin in a fertile soil must be considerable. Veldkamp [21] showed that chitin is broken down by many species of bacteria and actinomycetes from soil. Two species were found to break down chitin to the same end-products; acetic acid and ammonia. It is therefore apparent that chitin must be a considerable source of ammonia in most soils. The third source of ammonia is perhaps a rather doubtful one; the secretion of ammonia into the soil by nitrogen-fixing bacteria. Winogradsky [23] found that ammonia is liberated by young *Azotobacter* cultures growing in a liquid medium. Neither he nor anybody else has definitely been able to prove that growing *Azotobacter* produces free ammonia in soil, but it is quite possible that ammonia is supplied by this means. Anyway, it is apparent that a very large variety of bacteria and other micro-organisms can supply ammonia to the soil in various ways.

The Nitrifying Bacteria

In contrast to this, the last stage of mineralization, i.e., the oxidation of ammonia to nitrate, is carried out only by a very small number of rather peculiar species of bacteria; and in this lies the great interest of nitrification to the microbiologist. Warington [22] showed, as long ago as 1879, that nitrification takes place in two stages; the ammonia is first oxidized to nitrite, and then the nitrite is oxidized to nitrate.

The reactions concerned may be written:

$$2\ NH_3+3\ O_2=2\ HNO_2+2\ H_2O+79\ \text{kcal.; and}$$
$$HNO_2+\tfrac{1}{2}\ O_2=HNO_3+21.6\ \text{kcal.}$$

In both these reactions heat is given off (they are *exothermic* reactions). They can therefore be used as a source of energy; and they are in fact the only source of energy which the nitrifying bacteria are able to use. Ordinary bacteria, like fungi, and like man and other animals, are *heterotrophic;* that is, they must have a supply of preformed organic compounds to use as the source of the energy they need to live and grow. Green plants on the other hand are *autotrophic;* they are not dependent on organic compounds for energy because they are able to use the energy of sunlight. The nitrifying bacteria are autotrophs too, but of a peculiar kind; because they have no pigment such as chlorophyll, they are not able to use light as a source of energy. They are also unable to use organic compounds; why this should be so is not clear, but it may be that the cell-wall of the nitrifiers is of such a nature that organic compounds cannot penetrate it. They have therefore only one possible source for the energy they need to live and multiply; they must use the oxidation reaction which turns ammonia into nitrite, or nitrite into nitrate. Nitrification is therefore absolutely essential to the nitrifying bacteria. The true nature of these bacteria was discovered by the great Russian bacteriologist, Winogradsky [23], who first isolated them in pure culture and grew them on media free of organic matter. He gave the name *Nitrosomonas* to the ammonia-oxidizing species that he isolated in 1891, and called the nitrite-oxidizing species that he obtained at the same time *Nitrobacter*.

It has sometimes been claimed that nitrification is not due, or at any rate not wholly due, to the autotrophic nitrifying bacteria. These claims may be correct, but there is no satisfactory proof of them. Dhar and his school in India (see [20] for instance) claim that nitrification in tropical soils is not a biological process at all, but is entirely due to the action of sunlight, with various metal oxides acting as catalysts. This is a most interesting hypothesis, but quite unproved. Again, some bacteriologists think that nitrification is due to the combined activity of many different species which form small amounts of nitrite. The difficulty of accepting this hypothesis lies in the fact that the amounts formed in culture by such organisms are so very small, seldom exceeding 5 p.p.m.; and also that nitrite is usually the substance reported. Nitrite is very seldom found in more than minute quantities in field soil, so that it must be oxidized to nitrate as fast as it is formed; and *Nitrobacter* is the only known species which can carry out this change, so that, if heterotrophs begin the process of nitrification, they cannot carry it through. Nitrite is known to be formed from the oximes of *alpha*-keto acids by certain heterotrophs [8], but it is not known whether these oximes occur in soil.

The autotrophic nitrifiers can oxidize ammonia on a much larger

scale than any heterotroph. If *Nitrosomonas* growing in pure culture is supplied with ammonia at intervals, it will oxidize it almost quantitatively until about 2 per cent of nitrite is present in the medium. *Nitrosomonas* and *Nitrobacter* grown together are more efficient still. Nitrite, which is a toxic substance even to the nitrifiers, is removed by oxidation to nitrate and, given the right cultural conditions, as much as 10 per cent of calcium nitrate can be accumulated in a mixed culture [16]. On these grounds alone it seems likely that they are by far the most important, if not the only agents of nitrification in soil. It may also be said that they seem to occur in fertile soils all over the world.

Organic Matter and the Nitrifiers

As far as is known, carbon dioxide is the only carbon source available to either *Nitrosomonas* [23] or *Nitrobacter* [14]. The nitrifiers are thus independent of, and in a sense indifferent to, organic matter. They can be grown for long periods of time in culture media which contain no organic substance of any kind. But there does not seem to be any truth in the old text-book statement that organic matter *as such* is poisonous to the nitrifiers, which is based on a single paper [24], that is far from convincing. Such a statement could only have been accepted by people who were ignorant of the conditions under which nitrate is formed in nature. Here the rule seems to be, the more organic matter, the better is nitrification.

In the fourteenth century gunpowder was invented, some say by Friar Bacon. One of its essential ingredients is saltpetre (crude potassium nitrate). Until the middle of the nineteenth century everybody knew where saltpetre was likely to be found. They scraped it off the walls of dirty stables, and of cellars into which the drains leaked, and they dug out the earth from under old houses, and even, I am sorry to say, from old graveyards, and washed the nitrate out of it with hot water. In the Napoleonic wars, when the British blockade cut the French off from their supplies of Chile saltpetre to make gunpowder, they resorted to an imitation of the natural saltpetre sites; they made "nitre beds", which were heaps of earth and manure inside wooden sheds. The beds were watered with liquid manure, and after about two years they were broken up and extracted with water to reclaim the nitrate [2]. In more recent years speculators have bought up the sites of abandoned villages in Egypt and India for the nitrate accumulated under the houses.

The reason why nitrification is thus associated with large quantities of organic matter seems at first sight to be simply that nitrogenous organic matter is a source of ammonia; but there may be more to it than this. Several writers have suggested that natural organic matter contains some kind of stimulant, or growth factor, for the nitrifying bacteria (see [17] for instance). But again this is an unproven hypothesis. Meiklejohn [11] and Gundersen [6] both tried a large number of possible growth factors; every substance tried had either no effect on the nitrifiers, or it hindered nitrification.

Nitrate Accumulation

There is very little nitrate in ordinary field soils; the nitrate nitrogen is only a small fraction of the total nitrogen, and seldom amounts to more than 10 p.p.m. But in certain soils, as in the old saltpetre sites, there are accumulations of much larger quantities of nitrate. There has been some confusion in the minds of soil chemists as to how this nitrate accumulation happens, since it is often observed in conditions which are obviously not suitable for nitrification; but in point of fact the nitrate formed by the nitrifying bacteria may be concentrated by purely physical processes, leaching and evaporation, in which the bacteria play no part.

The first condition for nitrate accumulation is, however, that the nitrifying bacteria must be there at the beginning to form the nitrate, and that their needs must be met. In the first place, they need an adequate supply of ammonia, and, as has been said, this explains the intense nitrification in spots where there is much decaying nitrogenous organic matter. They also need carbon dioxide, and of course water, as all living things do. Both *Nitrosomonas* and *Nitrobacter* need phosphate and magnesium [1] and iron [12], and *Nitrosomonas* needs calcium [9], but their needs for these nutrients are so small that almost any soil can meet them. And, of course, the nitrifiers need oxygen, as molecular oxygen takes part in the two essential reactions from which they obtain energy; so nitrate accumulation can only be expected in well aerated soils.

It has been known for some years that nitrate accumulates in the top soil of fallow fields in dry weather [19]. This is noticeable in England in hot summers, but is far more marked in the tropics. Griffith and Manning [5] observed accumulations of more than 100 p.p.m. of nitrate nitrogen in a Uganda soil during the dry season. The greater accumulation in the tropics is partly due, no doubt, to more intense nitrate formation; the optimum temperature for the nitrifying bacteria is about 30°C, which is seldom obtained below the surface of soils in England, but is normally found several inches below the surface of tropical soils during the day. The greater heating by day and cooling by night also draws air out of the soil and in again, and so tropical soils are very well aerated. But more intense activity of the nitrifying bacteria is not the only reason for the very high concentrations in the top few inches of dry tropical soils. Nitrate is very soluble, and so it gets pulled up to the surface when water is drawn up by evaporation, and here it remains so long as no rain falls. It is possible that the enormous accumulations of nitrate in the Chilean desert (Chile saltpetre) were formed by the gradual working of a similar process over thousands of years.

Losses of Nitrate

It might sometimes be advantageous to stop nitrification, because

nitrate is the form of nitrogen which is most easily lost from soil and manure heaps. The greatest losses in most soils are due to leaching. Nitrate is very soluble, and is not held on the soil colloids as ammonia is. In England all the nitrate in the top 6 inches is washed out by rain heavy enough to penetrate 20 inches of soil; it goes into the field drains and is lost [3]. In the tropics, the disappearance of nitrate from the top soil, under far more intense rainfall, is almost instantaneous; there may be a great accumulation of nitrate 3-4 ft below the surface, but this is of course out of reach of the roots of growing crops [15].

Some nitrogen is also lost by denitrification, the reduction of nitrate to nitrous oxide gas and free nitrogen which escape into the air. Bacteria which can do this are very common in soil, but, as they require a good deal of organic matter to reduce the nitrate, and as their activities are checked by aeration, they are fortunately not often effective in causing nitrogen loss.

Nitrification can be stopped by steaming the soil; this kills the nitrifiers, but tomato growers, who regularly steam their glasshouse soils, are troubled by the accumulation of ammonia which follows steaming [4]. The burning of vegetation above the soil has been shown to kill nitrifying bacteria in a Kenya soil, and it may be that the improvement in yields after bush burning in the tropics is partly due to the conservation of nitrogen when nitrification is stopped [13]. There are some chemicals, e.g., allylthiourea, which poison cultures of nitrifiers in minute doses [10]; they might be used to stop nitrification, but have not yet been tried.

Plant Roots and Nitrate

If there is very little nitrate in an arable soil, it does not necessarily mean that the nitrifying bacteria are absent or inefficient; they may be forming quantities of nitrate, which is taken up by the roots of the crop as fast as it is formed. Sometimes much is taken up by other soil micro-organisms; this effect is most marked when added organic matter has stimulated the growth of fungi. Some species of plant are independent of nitrate, e.g., coniferous trees and some grasses [7 and 18]; the conifers have mycorrhizal fungi on their roots, which probably help them to use other forms of nitrogen; at any rate nitrifying bacteria seem to be quite absent from the soils of pine forests. Some grass species seem to be not only independent of nitrate, but harmful to the nitrifying bacteria; Mills [15] found that there was no nitrate at all in the top six feet of a Uganda soil on which certain tropical grasses had been growing for three years. When elephant grass was removed from this soil, nitrification recovered in a few weeks; but after *Paspalum* the recovery of nitrification was very slow, and no nitrate was found in the soil for some months.

References

1. H. Bömeke. *Arch. Mikrobiol.*, 1949, **14**, 63.
2. J. B. Boussingault. *Économie Rurale*, 1844. Paris: Béchet Jeune.
3. G. W. Cooke, J. A. R. Bates and P. B. Tinker. *J. Sci. Food Agric.*, 1957, **8**, 248.
4. J. N. Davies and O. Owen. *J. Sci. Food Agric.*, 1954, **5**, 146.
5. G. ap Griffith and H. L. Manning. *Trop. Agric.* (Trinidad), 1949, **26**, 108.
6. K. Gundersen, *Physiol. Plant.*, 1955, **8**, 136.
7. H. Hesselman. *Medd. Skogsförsöksanst. Stockh.*, 1917, **14**, 297.
8. H. L. Jensen, *J. gen. Microbiol.*, 1951, **5**, 360.
9. T. Y. Kingma Boltjes. *Arch. Mikrobiol.*, 1935, **6**, 79.
10. H. Lees. *Biochem. J.*, 1952, **52**, 134.
11. J. Meiklejohn. *Proc. Soc. appl. Bact.*, 1952, **15**, 77.
12. J. Meiklejohn. *J. gen. Microbiol.*, 1953, **8**, 58.
13. J. Meiklejohn. *J. Soil Sci.*, 1955, **6**, 111.
14. O. Meyerhof. *Pflüg. Arch. ges. Physiol.*, 1916, **146**, 352.
15. W. R. Mills. *East African agric. J.*, 1953, **19**, 53.
16. Müntz and Lainé. *Ann. Sci. Agron. Sér. 3.*, 1907, **1**, 278.
17. T. J. Murray. *Proc. Soc. exp. Biol.*, 1923, **20**, 301.
18. H. L. Richardson. *J. agric. Sci.*, 1938, **28**, 73.
19. E. W. Russell. *Soil Conditions and Plant Growth*, 8th ed., 1950, 293. London: Longmans, Green & Co.
20. S. P. Tandon and N. R. Dhar. *Soil Sci.*, 1934, **38**, 183.
21. H. Veldkamp. *A Study of the aerobic decomposition of chitin by micro-organisms*, 1955. (Thesis, University of Leiden.)
22. R. Warington. *J. chem. Soc.*, 1879, **35**, 429.
23. S. Winogradsky. *Microbiologie du Sol*, 1949, Paris: Masson & Cie. 1892, 204; 1904, 259; 1932, 691.
24. S. Winogradsky and V. Omeliansky. *ibid.*, 212.

Writing and the Advisory Officer

HENRY EDMUNDS
County Agricultural Officer, Brecon

IN A LARGE ORGANIZATION like the N.A.A.S., where District Advisory Officers, County Agricultural Officers and Specialists meet frequently to attempt to solve the problems of a complex farming age, the necessity for co-operation, and for good team work, is essential. It is not the purpose of this article to elaborate in any way on this, for there can be no doubt about its desirability. But the Service is nevertheless composed of individual men and women, all of whom have their likes and dislikes, their personal opinions and views. Important as it is that each should benefit from the training and experience of the other, it is equally important that one's individuality should not be submerged. Therefore, over and above one's day-to-day work, there should be an opportunity to express one's own ideas and thoughts. This might be stated in another way by asking the question "What has been my own personal contribution to the better farming of my county or district?"

The answer to this question, which I believe to be most important, must vary from one person to another, but I suspect that the result, after an honest appraisal, would not be too satisfactory in many cases. At least it did not satisfy me when I first thought about it some years ago. Although work was proceeding fairly well, and I had some reason to believe that my colleagues and I were doing a little to shine a beam of technical light where we thought it was most needed, life was rather dull and a little boring. It would be an exaggeration perhaps to say that I suffered from a sense of frustration, but it might have come to that unless I could find some outlet, some way of doing something which could be regarded as "strictly personal".

A Door Opens

I thought of many things, which I discussed with many people, but somehow the outcome was never entirely satisfactory and my search for that elusive means of self-expression eluded me. But one day I happened to be talking to an ex-editor of one of our farming papers, and in the course of conversation he mentioned casually the enormous scope there was for semi-technical articles in the popular agricultural press. It seemed that the pukka scientist was too specialized a writer for such a medium; articles by writers with a foot in both the technical and farming camps were needed.

The prospect of doing something to fill this gap was an intriguing one. A careful scrutiny of the weekly and monthly farming papers, the numerous journals published by various commercial firms, and the Ministry's own journal, indicated that contributions made by officers of the N.A.A.S. were surprisingly small, although the opportunities

for every D.A.O. and C.A.O. were extremely good. No one was in a better position to write usefully, for the material was available in abundance—every farm visited had something or other worth noting.

With these thoughts at the back of my mind, the farms I visited assumed a new aspect; they had a new interest and were viewed from a double viewpoint—that of an adviser and of a potential writer. Many of the things I saw were very familiar because I had seen them before, but I asked myself, were they equally well known to farmers in other parts of Wales or even England? Perhaps they were, but perhaps not. Were the thoughts and ideas I had worthy of publication; were they topical; were they timely? Above all, how could I find out?

First Steps

About this time, some seven years ago, I had become involved in the development of the suckled beef calf trade, a new venture in the county. The technical problems of producing animals for this highly specialized business were interesting, but equally important was the need to make known throughout the country, the existence of the stock that would eventually be for sale. Advertising specific sale dates was a matter for the auctioneers, but advance publicity, setting out the agricultural background was desirable, indeed essential. This seemed an excellent opportunity to find out whether I had any sense of "news".

I wrote to the editor of a farming paper, pointing out the purpose of the new sales and at the same time offering to take one of his staff around a few farms to see the class and type of calves that would be sold. The reply was prompt, the farm visits were made, and the result was a most useful piece of publicity for the county. I had done something which was my own; neither was it very difficult to do the same sort of thing in fairly quick succession thereafter.

I studied the way these professional writers put their stories together, the type of language they used, the intermingling of long and short sentences, but above all, the small characteristics which were peculiar to each of them. The type of photographs they took, and the use made of photographs in the article itself, were very illuminating. Indeed some farms I took them to were subsequently described almost entirely by photographs, supplemented by a few words underneath each. There is sense in this, particularly when dealing with beef cattle, for a camera records far more accurately the indefinable thing called "quality". It was however somewhat disconcerting to realize that so specialized is a modern agricultural paper, that it needs a writer and a cameraman operating together as a team and that very rarely did one individual combine both qualities.

But disturbed as I was by this unexpected discovery, it was consoling to realize that I had the ability to spot the various things that would make an article. Before long I took the plunge and wrote a 1,500-word account of a local pig demonstration we held. It appeared on November

10, 1950, under the heading "Pigs and Plenty". I was very pleased to see my name in print and a few days after it appeared, the farmer of whom I had written asked me to go and see him. When I arrived he showed me about a dozen letters he had received from various parts of the country, which gratified him immensely. We discussed his suggested replies over a cup of tea.

Specialization

Pigs, however, were not important to the county, and so in the succeeding years I confined myself to various aspects of sheep and beef store cattle husbandry. The nature of one's writing activities will obviously vary according to the farming of the county or district, but as Breconshire is a large exporting county of store animals, which are not price guaranteed, semi-technical articles have considerable advertising value. More than this, it costs the farmers of the county just nothing.

Once a few articles had been accepted, and here I must pay tribute to the help and kindness of Mr. S. R. O'Hanlon, editor of "Agriculture", I began to pay closer attention to what has been described as the "writer's art". While it was fairly easy to picture mentally the outline of an article, I found, and still find, considerable difficulty in being able to develop and to expand on this framework when it comes to putting thoughts into words. The basis, the heart of any article of up to 2,000 words can probably be set out in less than half-a-dozen points, but to elaborate on these, to clothe them in greater detail, is not an easy job.

I believe that one reason for this is the wide difference between official writing of letters and reports, and an article. With the former, one tries to compress and condense thoughts into as few words as possible and then to use formal and perhaps impersonal, stereotyped language. This way of thinking and writing, when practised over a period of years, is not the best form of training for article writing, which needs the opposite qualities. This was, by far and away, the most difficult problem I had to face, and it is doubtful whether I'll ever completely overcome it.

Orientation

The best way of trying to achieve this sort of mental adjustment is to study the method and style of those agricultural writers whom one likes. It is a case of noting, not so much the facts themselves, but rather how they are expressed, and the type of words and phrases used. In addition there are many books published on the writer's art, but personally the modern author whose technique and advice appeals most to me is Somerset Maugham. In his book "Partial View", he states:

> *If you could write lucidly, simply, euphoniously and yet with liveliness, you would write perfectly.*

It is, however, one thing to know what to do; it is quite another to be able to do it.* I was, however, much encouraged when, some years ago I compared the style of writing of two books on sheep written by the same and now distinguished author. The first appeared in the late 1930s and the second was a fairly recent publication; there was a world of difference between them. Both revealed a competent technical mind but within a period of about twelve years, an immature, stiff and awkward style had given way to one of smoothness, polish and maturity.

Once I had seen my first article published, the inclination to rush and repeat the performance was too strong to resist. Ideas were never lacking, but it took me some years to realize that if writing was not to become sheer drudgery, a lot of thought and planning was essential before the first word was actually written. This takes time, but above all it takes patience to curb one's natural desire and inclination to get started. Doubtless different people have different ways of working, but in my own case I find it far easier and quicker to draft out headings and sub-headings and then insert the thoughts I may have on each particular point. This eventually gives a fairly complete outline. A careful scrutiny of the outline is then made to see if the order and sequence are right; often re-arrangement is necessary, such as shifting an intended remark or paragraph from one place to another. Only after I am fairly satisfied that the rough plan is about right, do I start the actual script.

Style of writing is a very personal thing. Some people have a natural flair for striking phrases, for choice words, for a fine vocabulary, but I found that I did not possess that most desirable gift. It can be developed however to a considerable extent, and for some years now I've kept a notebook in which I record any phrase, sentence, or paragraph which pleases me. A Dictionary of Quotations is also very useful; often these can be picked up in good second-hand condition for very little.

The best test of writing is to get it published. Once in print it is there for ever, and over the years few things have given me more pleasure than to go back over a cuttings book. To use the title of a popular TV programme, it is "All Your Own".

*Since this article was written, several N.A.A.S. regions have held short courses on writing for the press.

Reviews and Abstracts

Animal Breeding

The genetic connexion between body size, milk production and efficiency in dairy cattle. I. L. MASON, A. ROBERTSON and B. GJELSTAD. *J. Dairy Res.*, **24,** 135.

Genetic covariation between milk yield and fat percentage in dairy cattle. B. R. FARTHING and J. E. LEGATES. *J. Dairy Sci.*, **69,** 639.

Heritability and phenotypic and genetic correlation between type ratings and milk and butterfat production in Holstein-Friesian cattle. R. G. MITCHELL, E. L. CORLEY, E. E. HEIZER and W. J. TYLER. Abstracted in *J. Dairy Sci.*, **69,** 632.

The heritability of milk yield and fat percentage in the Friesian cattle in the province of Friesland. S. A. F. EL-SHIMY. *Z. Tierz. ZuchtBiol.*, **69,** 321.

These four papers are all concerned with the genetic control of milk production characteristics in dairy cattle, and their interrelations with one another. Though the numerical values of particular estimates may vary to some extent with country, breed and method of computation, it is gratifying to note a broad basis of agreement among authors in their main conclusions.

Heritability estimates for milk yield are generally rather low (about 25 per cent) while those for fat percentage are considerably higher (about 55 per cent), as has been found before. The breeder can therefore select efficiently for higher fat percentage but the response of milk yield to selection is likely to be sluggish. Total yield of fat is determined largely by total milk yield, because within a breed fat percentage shows relatively little variation.

It has often been suggested that a good milk yield and high fat content are inherently antagonistic. These investigations bear this out, to the extent that the genetic correlation between the two is negative. The strength of this negative relationship varies between breeds and countries, but seldom is it so strong that the selector could not overcome the tendency and improve both yield and fat content simultaneously, or at least hold one constant while he improves the other.

The association between milk yield and various body measurements was slight and the heritability of "dairy type" proved to be very low (6 per cent).

Mason *et al.*, working with Danish data, established a very strong relationship between milk yield and gross efficiency of food conversion. Within any given system of feeding, the most efficient cow is the highest yielder, but she would not necessarily remain so if feeding standards were changed.

R.C.R.

Aspects of Pig Feeding

Copper Supplementation

Following earlier observations made at the National Institute for Research in Dairying that copper is of special value in pig feeding, several further studies have been made. A trial [1] co-ordinated by N.I.R.D. but conducted in eight Institutes showed that the addition of 250 p.p.m. of copper to the diet caused the very slight but statistically significant increase in liveweight gain of 0.08 lb per day over the control without added copper (1.48 lb/day compared with 1.40 lb). However, the food conversion rate of 3.53 as against 3.62 was not significantly better. A comparison of the effect of copper with that of antibiotic seemed to show that the copper improved the food utilization whereas the antibiotic produced its effect through increased food consumption [2]. However, the number of pigs used was very small and a more extensive trial was carried out [3]. This further trial tended to show that significant increases in growth rate produced separately by copper, oxytetracycline and chlortetracycline were each accompanied by increased rates of food consumption and that the food conversion rates were not markedly different. The liver copper of the pigs fed 250 p.p.m. was eight times higher than that of the controls. Pigs fed five and ten times as much copper for a few days lost weight and appetite, but resumed normal progress when the copper was reduced to 250 p.p.m.

Work at another centre [4] using copper levels from 0 to 500 p.p.m. showed that up to 100 lb live weight the higher levels were more efficient, but no level had any effect between 100 and 200 lb, and overall the differences were not significant; 125 p.p.m. appeared to be the most favourable. Liver coppers rose steeply on levels above this. The value on the 500 p.p.m. level was on average about one hundred times greater than the control, and there was some indication of marginal toxicity.

On the whole, the benefit from copper supplementation appears to be slight, and unfavourable circumstances on the ordinary commercial farm could perhaps precipitate trouble from the potentially dangerous high liver-storage. Further, careless use of highly copperized pig food for other stock might have harmful consequences. A case is recorded [5] in which ewes given a pig meal containing 180 p.p.m. copper for four months died from copper poisoning some months later when subjected to unusual stresses.

Early Weaning of Pigs

"Artificial rearing" is by definition the taking of piglets from their mothers when only one or two days old and feeding them liquid milk substitutes. Solid food is gradually introduced and after a fortnight the change is complete. Owing to the great difficulty of achieving success, artificial rearing is usually considered to be an emergency operation to be tried only if the sow dies or if she has too large a litter to provide natural suckling for all. On the average farm no more than a 50 per cent chance of success may be expected. By contrast, "early weaning" means weaning the pigs from the sow at 10-14 days and bringing them immediately on to dry food. This is a much safer procedure, but of course it has no emergency value. Both methods are well described in a recent excellent review [6].

Among the carbohydrates, the newly-born pig can use only lactose and glucose but by ten days it has developed the power to use sucrose and other sugars [7]. This fact is applied in constructing rations used in early weaning and sucrose is now usually included. A series of papers [8, 9 and 10], report a long and careful investigation into the factors for successful early weaning. For pigs up to 25 lb live weight a ration containing 10 per cent sucrose and 29 per cent protein was found to be very suitable [8], most of the protein being derived from casein and fishmeal. There was no advantage in raising the fat from 3.7 to 7.0 per cent, and a special vitamin supplement was ineffective because, presumably, the ration was already rich enough by nature. A high level of antibiotic gave a significantly greater growth rate but did not control scouring. Scouring, when it occurred, was best treated by starvation for 24 hours. A special trace element mixture just failed to show significance. When the meal was fed wet scouring was slightly increased. A comparison [9] between weaning weights of 8, 14 and 20 lb showed that, of the three, the middle one was to be preferred when judged by the results at 50 lb; a ration containing 22 per cent protein was used from 25 to 50 lb live weight. Later work [10] showed that 18 per cent protein was just as effective for this range. A study of the papers themselves and also of the review [6] already mentioned would be well worth while to obtain practical details of diets and management.

The benefit from early weaning was that the sow could be served within three weeks of farrowing, thus saving six weeks of suckling and making possible an extra litter every two years. The severe loss in the sow's body weight after eight weeks' suckling was also avoided.

An interesting achievement, although not of early weaning, has recently been reported in the farming press [11]. This is the production of a litter of 18 Large White × Essex pigs which weighed 1,134 lb at eight weeks old, the average weight being 63 lb. The litter was divided at birth into two lots of nine and each lot was allowed to suckle the sow once every four hours. When one lot was being suckled the other received sow milk substitute, so that either natural or artificial milk was con-

sumed at two-hourly intervals by each group. A mixture of flaked maize and fishmeal in the proportions of 3 to 2 was made available and was taken almost from the beginning. After eight days a foster sow was brought in to take over one of the groups and *ad lib.* suckling for both took place thereafter. Other foods and additives were used lavishly and although the result may be labelled freakish, much patient ingenuity was shown in attaining it.

References

1. High-copper mineral mixture for fattening pigs. R. J. Bowler *et al. Brit. J. Nutr.*, 1955, **9**, 358-62.
2. Antibiotic and copper supplements for fattening pigs. R. S. Barber, R. Braude and K. G. Mitchell. *Brit. J. Nutr.*, 1955, **9**, 378-81.
3. Further studies on antibiotics and copper supplements for fattening pigs. R. S. Barber, R. Braude, K. G. Mitchell, J. A. F. Rook and J. G. Rowell. *Brit. J. Nutr.*, 1957, **11**, 70-9.
4. A comparison of five levels of copper sulphate in rations for growing pigs. I. A. M. Lucas and A. F. C. Calder. *Proc. Nutr. Soc.*, 1957, **16**, i-ii.
5. Copper poisoning in sheep following the feeding of a copper-supplemented diet. J. K. L. Pearson. *Vet. Rec.*, 1956, **68**, 766-8.
6. New developments in rearing pigs. R. Braude. *Outlook on Agriculture*, 1957, **1**, 175-81.
7. The utilization of carbohydrates in the young pig. A. M. Dollar, K. G. Mitchell and J. W. G. Porter. *Proc. Nutr. Soc.*, 1957, **16**, xii-xiii.
8. The early weaning of pigs. 1. The effect upon growth of variations in the protein, fat, sucrose, antibiotic, vitamin and mineral contents of diets for pigs of 8-25 lb liveweight and a comparison of wet and dry feeding. H. Smith and I. A. M. Lucas. *J. Agric. Sci.*, 1956, **48**, 220-35.
9. The early weaning of pigs. 2. The performance up to 56 days of age of pigs weaned at 8, 14 and 20 lb liveweight. H. Smith and I. A. M. Lucas. *J. Agric. Sci.*, 1957, **49**, 405-8.
10. The early weaning of pigs. 3. The influence of protein supply during two stages of growth on the performance of pigs from 9 lb to bacon weight. H. Smith and I. A. M. Lucas. *J. Agric. Sci.*, 1957, **49**, 409-18.
11. The world record litter. Anon. *Farmer & Stock-breeder*, 26 November, 1957, pp. 69-70.

S.M.B.

Dairy Husbandry

Plane of Nutrition of Dairy Cattle

During the last two or three years a few papers concerning original investigations and also a number of informed reviews have drawn attention to the problem of optimum plane of nutrition of dairy cattle in all phases of life including the period of rearing, late pregnancy and lactation. Most of the work is concerned with levels of starch equivalent or energy intake, and those of Blaxter, Reid, and Burt (K. L. Blaxter, *Proc. Brit. Soc. Anim. Prod.*, 1956, 3; J. T. Reid, *Mem., Cornell Agric. Exp. Sta.*, 1956, No. 344; A. W. A. Burt, *Dairy Sci. Abstr.*, 1956, **18,** 884 and *Dairy Sci. Abstr.*, 1957, **19,** 436) are particularly apposite.

It is difficult to determine the optimum *economic* plane of nutrition during rearing because of the lack of published evidence of the long-term *physical* effect of various planes of nutrition. Investigation of this is going forward at various centres but the most substantial evidence so far published has been obtained in Sweden, and some aspects have been reported by A. Hansson (*Proc. Brit. Soc. Anim. Prod.*, 1956, 51). This carefully controlled work on substantial numbers of identical twins showed that the lower planes of nutrition used during rearing resulted not only in higher milk yields in subsequent lactation but also tended to increase the length of the cow's life. Under British conditions the rate of growth and hence the plane of nutrition in the rearing heifer is often dictated by factors other than nutritional and physiological efficiency, such as the frequent need to calve heifers in autumn or to calve heifers at a younger age and reduce the number of unproductive young cattle on the farm. Nevertheless, if the Swedish findings are confirmed in other investigations there will have to be strong economic counter reasons for a high plane of nutrition especially where costly concentrates are used during the period from, say 4- or 5-months-old up to the time of "steaming up" for calving. The practical farmer may also wish to bear in mind the remarkable rate of growth which the rearing heifer will normally make when she is changed from a low to a high plane of nutrition. This was noted by workers at the Rowett Research Institute (J. A. Chrichton and J. N. Aitken, *Proc. Nutr. Soc.*, 1954, **13,** 10) and has been the experience in many other similar investigations. There seems no strong technical objection to a fairly low plane of nutrition and a modest rate of growth in the winter, if the more liberal plane of nutrition on summer grazing accelerates growth back to normal.

In the various studies of the effect of raising the plane of nutrition in the last few weeks before calving, or, in other words, "steaming up", the response in terms of extra milk produced, has usually been worth more than the extra feedingstuffs used. For example, in one recent investigation (National Institute for Research in Dairying, 1956) an extra 1½ cwt of concentrates fed in late pregnancy to heifers resulted, on average, in about 200 lb more milk in the first 12 weeks of lactation. Some investigators

have sought to compare the milk yield response of a particular quantity of concentrates given before calving with that of the same quantity given as an extra ration during lactation. Generally, with normal levels of feeding the extra concentrates given before calving are the more effective.

In the reviews of the effect of plane of nutrition during lactation, certain conclusions have often been reached by research workers which are not generally known to the practical feeder who must, of necessity, work to a simple rationing scheme. One of these is that as milk yield is increased by raising the level of concentrate feeding, the extra starch equivalent required to produce each extra increment of milk produced also increases. Thus the law of diminishing returns operates in response to increasing concentrates fed. Clearly, the normal schemes of rationing on the basis of a set amount of concentrates for each gallon of milk produced, irrespective of level of yield, makes no provision for the higher starch equivalent cost of the high yield. For the moderate yielding cow this is of little practical significance, but failure to provide for it in the potentially high yielding cow may lead to loss of body weight or to failure to make the most economical use of the cows available. Recent reviews on cattle feeding frequently suggest that the level of feeding of concentrates to the milking cow might be determined on a direct economic basis, and that the amount fed should be increased until a point is reached where the value of the extra milk produced is just greater than the value of the extra increment of concentrates fed. Blaxter (K. L. BLAXTER, *Proc. Brit. Soc. Anim. Prod.*, 1956, 3) has from time to time suggested a more dynamic approach to rationing, presumably with this idea in mind, and it is perhaps surprising that practical systems of control of concentrate feeding on this basis have not been more commonly tried.

Solids-not-fat

Two recent studies of the composition of milk of individual cows in herds over a period provide further evidence on the factors affecting the s-n-f content of herd milk. Griffiths and Featherstone (T. W. GRIFFITHS and J. FEATHERSTONE, *J. Dairy Res.*, 1957, **24**, 201) have published details of the s-n-f content of the milk of cows in a number of herds in the West Midlands, while other workers (L. W. SPECHT, J. R. BRUNNER, D. E. MADDEN and N. P. RALSTON, *J. Dairy Sci.*, 1956, **39**, 1337) give details of the composition of the milk of cows in two Jersey herds in Michigan. The West Midland herds were tested because they had a history of low s-n-f and the overall mean s-n-f content was 8.43 per cent. The Michigan Jerseys produced milk with a mean content of about 9.50 per cent s-n-f. In spite of this big difference in the mean content of s-n-f in the two surveys, the trends with progress of the individual lactation in both followed the usual pattern, falling to the lowest level at about the stage of peak milk yield and gradually rising from that point till the end of lactation. The West Midland results again indicated that the late winter and late summer are the seasons associated with the greater incidence of low s-n-f, while the fall in mean s-n-f percentage from one

lactation to the next was about 0.1 per cent. This reduction was similar to that of other recent surveys and again showed that the age of the cows in a herd may be an important factor in determining the s-n-f content of the herd milk.

It has frequently been shown that the s-n-f content of milk can be reduced by feeding *below* the conventional standards for starch equivalent. Recent work at the Hannah Dairy Research Institute (W. HOLMES, D. REID, D. S. MACLUSKY, R. WAITE and J. N. WATSON, *J. Dairy Res.*, 1957, **24,** 1) has shown that the s-n-f content of milk may also be affected by plane of nutrition when the amount of food consumed is apparently *at or above* the Woodman starch equivalent standards. Experiments at the Hannah Institute showed clearly that a diet of grass products alone may result in a substantially lower intake of dry matter and starch equivalent compared with a diet of grass products and concentrates. The low intake of dry matter when cows are placed on an all silage diet has also been demonstrated at Shinfield (National Institute for Research in Dairying (1957) Rpt. 1956, 41). The intake of dry matter would also be lower with a "wet" silage (about 19 per cent dry matter) than with a "dry" silage (about 27 per cent dry matter) even when the chemical composition of the dry matter is similar in the two cases.

Grass and the Dairy Cow

Although the Seventh International Grassland Congress in New Zealand in November 1956 was concerned mainly with the more fundamental aspects of grass production and utilization, some of the papers presented are of direct interest to the dairy farmer. A brief report on the papers has been prepared (A. S. FOOT and W. F. RAYMOND, *J. Brit. Grassl. Soc.*, 1957, **12,** 63), and the complete papers together with discussion concerning them have now been published in New Zealand. (*Proc. Seventh International Grassland Congress.*)

An interesting paper from the practical point of view was No. 12 by C. P. McMeekan. In it he attempted to assess the main factors involved in efficient pasture utilization. From a review of thirteen large-scale grazing experiments he concluded that rate of stocking had been a major factor in determining the efficiency of grass utilization, but that the method of grazing, for example, rotational or set stocking, was of relatively little importance. These findings vary, of course, from the results of a number of investigations in the northern hemisphere in which strip folding has been reported to increase milk output per acre by up to 20 or 25 per cent. It is, therefore, not surprising that considerable discussion arose from McMeekan's paper. In the discussion he made the point that in New Zealand they would not recommend the use of the electric fence during flush periods of pasture growth but would use it to ration feed in times of shortage. This is, perhaps, a main reason for the different experience in the United Kingdom and in New Zealand. Although an absolute shortage of grass may not be much more common in this country than in New Zealand, the case for strict rationing of grass is greater

because the need to preserve grass as silage or hay is generally much more pressing than in New Zealand where winter feeding is often of short duration. There seems to be a case for greater care in assessing stocking rates, particularly where the object is to achieve a high milk output per acre. As was pointed out in the discussion on McMeekan's paper "as rate of stocking is increased, animal production increases to a peak, then falls. The best policy is to remain just on the safe side of the peak."

At the Ruakura Research Station in New Zealand a considerable amount of information has been collected on the consumption and digestibility of various swards when consumed by dairy cows. Newer techniques have greatly improved the precision of this work. In Paper No. 11, L. R. Wallace described some of their results, and it is of interest to note that he estimated the maintenance requirement of the grazing cow to be 80 or 90 per cent above the standard commonly used in Britain for stall-fed animals. There has always been doubt as to the extra starch equivalent required to provide for movement, foraging, grazing, etc., and obviously this must depend on quality of sward, topography, etc., although it seems that previous estimates of these requirements tended to be too low.

A number of papers at the Congress referred to various aspects of animal health in relation to a grass and clover diet. Examples of a high content of ammonia in the rumen on high protein grass diets were reported and its significance discussed. It seems that deaths in sheep and lambs may be associated in some circumstances with this condition, but no evidence of detrimental effects of high protein swards on dairy cattle was presented and t'Hart (Paper No. 5) on the basis of Dutch investigations could not support the suggestion that grass with a very high protein content will necessarily depress milk yield. His data did, however, indicate that with heavy dressings of potassic fertilizers, the incidence of grass tetany is substantially higher when dressings of nitrogenous fertilizers are also heavy.

The Congress also covered several aspects of mineral nutrition in both plant and animal. For example, three papers dealt with the incidence of molybdenum toxicity (teart) and hypocuprosis and the inter-relationship of molybdenum, copper and sulphate in these disorders (Papers Nos. 31A, 33 and 34).

A clear technical explanation (Paper No. 6) of the effect of overgrazing and slow sward recovery on the basis of incomplete light interception during the early stages after cutting and grazing emphasizes the need for avoidance of overgrazing or of too close cutting of pastures.

A.S.F.

Herbage

The Seventh International Grassland Congress

The Seventh International Grassland Congress was held in New Zealand during November 1956. An admirable summary of the fifty-odd papers has been given by Foot and Raymond [1]. It is felt that several of the papers were of sufficient practical importance to justify further consideration.

Intensity of Defoliation and Herbage Production

It has generally been accepted in this country that "on and off" grazing (whether by rotating paddocks or strip-grazing) gives better control of management and a greater increase in production than set-stocking or continuous grazing. Several papers indicated that more attention should also be paid to the intensity of grazing, particularly in relation to the height of defoliation. This idea was discussed by Sears [2] when reviewing various aspects of the interaction between the grazing animal and herbage species. After defoliation, the rate of herbage regrowth depends not only on the amount of food reserves in the roots and stubble, but also on the amount of photosynthetic tissue left on the plant. Both Sears [2] and Donald [3] quote Brougham's work to show that after very close grazing the initial recovery was very slow. The growth increment increased as the amount of leaf increased until enough herbage had been produced to give complete light interception. There was then a period of maximum regular growth increment up to a stage when internal shading, plus loss of leaf through decay, gave a final period of net unproductiveness. This growth increment curve was shown to be sigmoid, and with a mixture of short rotation ryegrass and white clover the maximum growth increment and full light interception were achieved when the ratio of leaf area to ground occupied was 5:1—this figure is referred to as the Leaf Area Index (L.A.I.). It is highly probable that the maximum L.A.I. will vary with species and environment; thus, in an environment different from the above, subterranean clover was found to have an L.A.I. of 8.5. The practical implications of this work are that frequent and relatively lenient defoliations (sometimes called lax rotational grazing) may produce more total herbage than infrequent and severe grazing.

Sears pointed out that grazing managements may be influenced by considerations of palatability and nutritive value, the need to resist weed invasion and the differences in growth habit between species, so that there can be no simple recipe for the best defoliation height. With *Agrostis*, close continuous, or rapid rotational grazing produces the best yield of animal feed. Perennial ryegrass and white clover are characteristically at their best under intensive rotational grazing with occasional defoliations severe enough to prevent mat formation by rough-stalked meadow grass. On the other hand, the more erect herbage species such

as cocksfoot, timothy, short rotation ryegrass, red clover and lucerne all provide optimum feed when defoliation is lax and when growth intervals between grazing are longer than for perennial ryegrass.

Jantti and Kramer [4] presented a further interesting contribution on the desirability of not grazing too severely during drought. They suggested that the recovery of closely defoliated plants is limited not only by the lack of photosynthetic material, but also by a reduced rate of water intake. Experiments were carried out in Finland on leys containing meadow fescue, cocksfoot and white clover. These swards were cut to various heights under different water conditions. The results showed that although the moisture tension exerted by an uncut plant was up to 15 atmospheres, that exerted by an almost completely defoliated plant was only 2 atmospheres. In addition, the lower the water content of the soil the more severely did defoliation reduce the re-growth of herbage. Thus the recovery growth of plants defoliated at heights of 1 cm. and 12 cm. above soil level was 56:100 in moist soil, but only 24:100 in soil near the wilting plant. This could obviously have important repercussions on the productivity of pastures during drought. The tendency to graze pastures bare during dry conditions in summer probably causes the total growth of the herbage to be much less than it would be if the grazing was not quite so severe, but more frequent.

Plant Density

Donald [2] presented useful data on the influence of plant density upon pasture productivity. The density of pasture stands, particularly if composed of annual species, can vary considerably. If the density is low the individual plant yield will be high and *vice versa*. However, the concern of the grassland worker is with yield per unit area rather than per plant, and results from annual swards of subterranean clover and Wimmera ryegrass demonstrated the relationship between production and density. As the density increased so did the final yield, and there was no tendency for this yield to fall, even though the density was so high that the grass remained single-tillered up to maturity. The manner in which the final yield was achieved varied according to the density. Thus plants at a low density grew at first without competition, but the yields were initially low, and even at the end of the season did not equal those of the denser swards. Conversely, the denser swards achieved a substantial proportion of their final yields while still in the seedling stage, but thereafter suffered progressively more and more from competition between plants as water, nutrients or light became limiting. The final yields from moderate and very dense stands were equal and depended on the supply of the limiting environmental factor, but the early production was strongly dependent upon density, and it is clear that in annual swards only dense stands will give good early production. This has obviously practical implications in this country particularly when one-year leys of Italian ryegrass are used for out-of-season grazing.

The picture for perennial plants is different and also more complex. During the first year the relationship between density and yield is similar to that for annuals—the maximum yields being obtained at medium or high densities. In succeeding years the population tends to adjust itself to the environment and the plant population of dense swards usually declines until a state of equilibrium is reached. Despite this thinning, the final density is not necessarily low enough for maximum production. An example was quoted where the maximum production of five-year-old lucerne was obtained at a density of approximately three plants per square foot. Lucerne sown at a very high density had thinned out to 8-12 plants per square foot, but this was still too dense to give maximum production. It follows, therefore, that excessive sowing rates of perennial species, even though able to give high production in the first year, will not necessarily give maximum long-term yield.

Legumes and the Nitrogen Cycle

It is well known that appreciable quantities of nitrogen may be transferred from legumes to associated grasses via the dung and urine of grazing animals, but in the paper presented by Butler and Bathurst [5] the emphasis was on the underground transference of nitrogen from clover to grasses.

It has been shown in the past that leguminous plants may excrete nitrogenous compounds likely to be of benefit to grasses, but there have been numerous other instances where no such excretions have been noted. Butler and Bathurst concluded that this phenomenon was only likely to occur where there was a luxury accumulation of nitrogenous metabolites of low molecular weight in the root system of legumes. This state of affairs appeared improbable under pasture conditions, and consequently the excretion of nitrogenous compounds was not likely to be of major importance as a source of nitrogen for grasses. It was also considered that the leaching and decay of clover leaves was not likely to provide more than minute quantities of nitrogen. From the data provided it appeared that the major underground transference of legume nitrogen was by the decay of nodules and root tissue. Thus it was calculated that approximately 70 lb nitrogen per acre was released to the soil by the sloughing-off of nodules and their subsequent decay. Similarly the decay of leguminous root tissue was estimated to provide up to 30 lb nitrogen per acre.

In New Zealand, greater emphasis is generally placed on the importance of white clover as a source of nitrogen than in western European countries, and one possible reason for this is the higher cost of nitrogenous fertilizers in New Zealand. In addition, the valuable work of Mitchell [6] on the optimum environmental conditions for different herbage species has indicated that the climatic conditions in New Zealand are more suited to the growth of clover throughout the year than in western Europe. Thus the optimum growth of white clover is obtained at about

75°F, whilst below 65° the growth rate declines rapidly and is quite small at 45°. (It is interesting to note that the optimum temperature for ryegrass is about 55°.)

The use of nitrogenous fertilizers on pastures was discussed in detail by Walker [7]. Linear responses had been obtained between soil nitrogen and the yield of grass in pure stands. At high rates of application yields of dry matter ceased giving a linear response before yields of nitrogen in the herbage. It was suggested that, because of the linear response of grass to nitrogen over a wide range of application, it might be preferable to apply relatively high rates of nitrogen to selected grass-dominant fields, and to allow legumes to make their full contribution in other fields. Fertilizer nitrogen is sometimes useful in the establishment of legumes, and white clover has also been shown to utilize mineral nitrogen. Nevertheless, in a mixture of Italian ryegrass and white clover the grass was shown to take up 95 per cent of the mineral nitrogen used by the association. This additional nitrogen stimulates the grasses and therefore increases their ability to compete for light, nutrients and moisture. If the supply of either nutrients or water is unsatisfactory it appears that, in the presence of adequate mineral nitrogen, the grass will compete more successfully for the limiting nutrient or water than will clover. Where nutrients and moisture are adequate, competition for light becomes the major factor determining the yield of clover, and the height to which grass is allowed to grow before utilization is of major importance. Frequently, moderate applications of nitrogen may result in a decreased total yield of herbage owing to the suppression of clover, whilst heavier dressings may again give higher yields. However, it should be borne in mind that it is often economic to use fertilizer nitrogen for out-of-season grass (*e.g.*, early spring grazing) although subsequent clover production may be lowered.

References

1. Report on the papers read at the Seventh International Grassland Congress. A. S. Foot and W. F. Raymond. *J. Brit. Grassl. Soc.*, 1957, **12**, 63-73.
2. The effect of the Grazing Animal on Pasture. P. D. Sears. *Proc. Seventh International Grassland Congress*, 1956, 92-104.
3. Competition Among Pasture Plants. C. M. Donald. *ibid*, 80-91.
4. Regrowth of Pastures in Relation to Soil Moisture and Defoliation. A. Jantti and P. J. Kramer. *ibid*, 33-44.
5. The Underground Transference of Nitrogen from Clover to Associated Grass. G. W. Butler and N. O. Bathurst. *ibid*, 168-78.
6. The Influence of Light and Temperature on the Growth of Pasture Species. K. J. Mitchell. *ibid*, 58-69.
7. Nitrogen and Herbage Production. T. W. Walker. *ibid*, 157-67.

H.K.B.

Poultry Husbandry

Increased egg production in this and other countries where poultry-keeping is a major agricultural activity has tended to depress profit margins per egg. In their efforts to reduce the chief production cost—food—poultry-keepers have directed more attention to ways and means of economizing in this field without adversely affecting egg production. The most expensive item in the food bill is protein and particularly animal protein. From time to time it has been argued that too much protein is included in the diet, or alternatively, that it would be more economical to increase the level of dietary protein in the hope that a substantial increase in egg production would offset the increased charge. Recently, this particular aspect of the most economical level of dietary protein has been reviewed, and an account given of experiments with various protein and energy levels in combination in "Minimum Protein Requirements of Laying Pullets at Different Energy Levels" by E. C. Miller, M. L. Sunde and C. A. Elvehjem (*Poultry Sci.*, 1957, **36**, 681-90). They found that good egg production was sustained with their experimental diet with dietary protein at a level of not less than 12.5 per cent. An increase of above 13 per cent in the protein level did not lead to any increase in egg production. The authors add a word of warning on the quality of the protein to be used, stressing the need to maintain the amino-acid balance in the ingredients of the ration, particularly when the protein content approaches the critical level. It is pointed out that amino-acid deficiencies may be the reason for a lowered egg production sequential to a ration with a total crude protein in excess of 13 per cent.

In these experiments good egg production was secured even when the calories of productive energy of the diets ranged from 31 to 86 for each per cent protein. It therefore appears that a wide calorie-protein ratio in the diet can be tolerated by the laying pullet without affecting egg production. Egg weight was not influenced by decreasing the protein level with the various energy levels used so long as some animal protein was included in the rations.

Early Production of Large Eggs from Pullets

This reference to egg weight is of some interest in the light of conclusions reached by some of the researchers in Texas. In a paper entitled "Feeding and Management of Replacement Broiler Stock" by R. J. Couch, R. E. Issacks, B. L. Reid, W. P. Crawford and J. H. Quisenberry (*Feed Age*, 1957, **10**, No. 4, 33-9), the authors review the many attempts to secure large eggs at an early stage in the laying cycle. They point out that this need is of special importance to poultrymen mating stock for hatching eggs to produce chicks reared for the broiler market. Although this particular aim is not at present of much moment in the United Kingdom, poultry-keepers are anxious to produce large eggs from their pullets as soon as possible in view of the recent favourable prices for large eggs.

The various methods have been a reduction in the protein level of the diet after the early chick rearing stage, range rearing as opposed to intensive methods, restricted feeding and an increase in the fibre content. The authors draw attention to the inconsistent results achieved by all these methods reported by numerous workers. In their experiments diets were used which contained the same level of protein but differing energy levels. In addition, the several rations were supplied *ad lib.* to some groups and restricted to 70 per cent of the normal intake to other groups. The results showed that the critical factor inducing the early production of large eggs was a reduction in the energy level of the food—and to a lesser degree the restriction in the diet where this had a rather similar effect, *i.e.*, a reduction in the total energy food available to the bird. It was, however, found that the egg production of the groups subjected to some form of restriction in the diet—either a reduction in quantity or in the amount of energy available—was delayed some 14 to 28 days compared with the birds fully fed a high energy diet. The mortality rate was substantially higher in the groups receiving the restricted diet.

While, therefore, the aim of producing large hatching eggs early in the laying cycle was achieved, it did involve slightly delayed egg production and also a higher rearing mortality in those groups whose diet was quantitatively restricted. Unfortunately, the authors give no account of the costs involved and it is impossible, therefore, to assess the saving in feeding costs and increased income from early saleable hatching eggs against the losses through mortality and delayed egg production. It should perhaps be emphasized that the conclusions advanced by the authors are in opposition to most of the opinions held by poultrymen although, as already stated, those opinions are based on methods which have not given consistent results. Nevertheless, the standing of the Texan research workers is such that their conclusions cannot be easily dismissed —but a repetition of the work with other strains would seem desirable before complete reliance is placed on the method.

Range or Intensive Methods for Breeding Stock ?

Another commonly held theory which has recently been investigated is that concerning the management of breeding stock on range as opposed to intensive methods. The great majority of breeders prefer to house their stock in some form of house sited on a grass pen. Apart from the belief that the bird does better in the open than in an intensive house, it seems generally accepted that grazing on the grass sward confers certain not precisely specified advantages. The belief has recently been investigated by workers at Reading University and their findings are described in a paper on "The Value of a Grass Sward for Breeding Hens" by D. J. G. Black, T. R. Morris and J. A. Palgrave (*Poultry Sci.*, 1957, **36**, 780-8). In their experiment birds were housed with pens having an old-established sward, while others were similarly housed but the turf was removed and any traces of vegetation periodically removed from their

pens. Six rations were used in which the protein level ranged from 11.6 to 17.6 per cent while the level of certain vitamins also differed. The idea was that birds on sub-optimal rations might derive more benefit from grass than stock supplied a completely balanced diet. The six rations were supplied to groups of birds housed with both grassed and grassless pens. Records were kept of egg production and over a period eggs were incubated in order to investigate the influence (if any) of grass on hatchability. The cockerels used were rotated round all the pens and fed separately with a standard breeder's diet.

Results showed that management on grass pens did not lead to any saving in the quantity of food consumed. The stock having access to grass runs did not manifest any better egg production, fertility or hatchability than the hens running on bare earth. But those birds in the grass pens did evince a marked increase in the riboflavin, Vitamin A and pigment content of the eggs over their fellows in the grassless pens. Apart from these unexpected findings the authors draw attention to the progressive depression in the hatchability level in the eggs produced from those birds fed increasing quantities of white fish meal. The main findings of this interesting experiment add force to the slowly increasing volume of opinion in this country that birds mated on range have no advantages over those mated under intensive housing. The latter method has, of course, much to be said in its favour on grounds of cost.

R.C.

Regional Note

Farm Circuits and Work Study in Lancashire

A. H. FITTON
National Agricultural Advisory Service, Lancashire

THE BRITISH PRODUCTIVITY COUNCIL and its local committees have played an important part in bringing to the notice of industry the need for improved productivity by the use of better techniques and equipment. In the past, much of their work has been in connection with industries other than agriculture, but the need for improved productivity in the latter is just as great, and recently some of the Local Productivity Committees in this county have begun to co-operate with the N.A.A.S. in this work by setting up farming sub-committees. This development is mainly centred on the Preston Productivity Committee working in conjunction with a similar organization in the Blackburn area but it has also been developed to a lesser extent in other parts of the county.

The farming sub-committee, as does the Council, includes representatives of both employers and workers as well as the N.A.A.S. and the Local Education Authority.

To develop the farming side of productivity work the Preston sub-committee decided to try out the circuit scheme which has been practised for some time by the Local Productivity Committee in its work in other industries. In effect, the circuit consists of a number of employers and their workers interested in some particular subject, each person visiting in turn the factory or premises of the others. To apply this principle to agriculture, the sub-committee invited a number of farmers whom they thought might be interested in such a scheme to discuss the idea. Fortunately, the committee started with the advantage of knowing how such schemes had been run in other industries in the area so, in the first instance, it was decided that the farmers to be invited would be those who were likely to be interested in the scheme and who in the future could give a lead to others.

Subjects to Suit Local Interest

Farming in the district around Preston consists of intensive milk, egg and pig production in the lowlands to the north of the town, intensive arable to the south in the freely working soils of south-west Lancashire and some upland dairying to the east. Farmers were invited from the three districts concerned and as a result of these discussions it was decided to try two circuits, one on the maintenance of farm machinery for the farmers in the Fylde and Ormskirk districts, and another one on grass conservation equipment for the farmers in the more eastern side of the county. There were six farmers in each circuit and each agreed to

show the others how they had approached the particular problem to be discussed.

At each circuit visit it was found possible to include something in which the farmer concerned had taken a special interest and which had had its effect on the efficient running of the farm. At the circuit dealing with machinery maintenance, for instance, one of the members was found to take a special care of his equipment, all of which is regularly cleaned and is painted annually. As a result, it not only looks as good as new but his repair bill is very materially reduced. This example made a great impression on the others, some of whom have taken steps to follow it.

Another member of the circuit had a very useful farm workshop and a number of other items as, for example, a simple gauge for measuring the fuel in his tractor fuel tanks, which was noted by the rest of the circuit and has since been copied by some of them. Yet another member, who mixes a large amount of stockfeed each year, had installed an automatic lift which not only raised the grain to the loft but was also capable of delivering it into the storage bins.

At the end of this particular circuit, one of the members, who is noted for being an excellent and up-to-date farmer, acknowledged that during his visits to the other farms he had picked up and listed at least twenty ideas for carrying out various operations which were better than those previously practised on his unit and that, in fact, many of them had already been adopted.

The other circuit worked in much the same way and was also organized by the N.A.A.S. in such a way that many different types of grass conservation equipment could be seen. These included small, home-made, grass driers, commercial grass driers, barn hay driers and mechanized methods of handling silage. The member with the large commercial drier was particularly impressed by the simple and effective working of the smaller farmer's home-made grass drier, which had enabled the latter to be more or less independent of weather conditions in the area concerned, even though it is one with a rainfall of 50-55 inches.

Organization

Most of the work of organizing and running these small circuits has been carried out by the N.A.A.S., either by a District Officer or by the Farm Machinery Officer, since the N.A.A.S. is in close touch with farmers and in the best position to make the necessary arrangements. It has also been found important to have a N.A.A.S. officer present both to help and organize the visits on the right lines and to deal with some of the more technical problems which always arise on these visits.

The Adviser is helped in his work by seeing examples of the farmers' methods and improvements. He is also able to utilize this experience in his day-to-day meetings with other farmers. A further point of especial importance in circuits of this kind is that although a farmer may himself think that he has nothing on his holding which can be of help to others,

our experience has always shown that in small groups of this kind even the most up-to-date farmers can learn from their neighbours, if only on one particular detail or the application of some modern technique.

It is important in organizing a circuit to ensure that the farmers who have participated in a number of schemes should be able to visit new farms which they have not previously visited and so far this has been possible.

The organizing and co-operation with the Local Productivity Committees in running the circuit schemes to the limited extent to which they have so far been developed has been an interesting experience to the officer concerned in the psychology of the work. While not being precisely an individual approach, it is not an impersonal group approach; every member of the circuit acts in a limited way as an adviser and the District Officer acts as a co-ordinating officer, interpreter and technical authority, and is greatly appreciated in that role.

Spread of the Circuits and Their Impact

During the last two years further circuits have been organized in the same way dealing with other subjects. Two circuits covered the subject of the home mixing of feedingstuffs, and in the summer of 1957 four circuits, including farmers from the Lancaster area, were organized to study how farmers had approached the problem of reducing milk production costs. This very topical subject formed a basis of valuable circuit meetings and has undoubtedly been of great advantage to the farmers who have participated. As a follow-up of this, further circuits are being run this winter on the same subject.

The Warrington Productivity Committee have followed the example of their colleagues in Preston and have set up a Farming Sub-Committee by which three or four circuits have been initiated.

Undoubtedly this type of small farm walk dealing with a particular aspect of the farm is a useful approach to technical development work and the N.A.A.S. has taken a very active part trying out and developing this technique. The same approach could be used in other sections of the industry to deal with many other problems and, in fact, it is anticipated that this will occur. There is an opening for it among specialist glasshouse growers, among poultry keepers and in many other aspects of farming other than those which have already been studied.

While much greater numbers can be dealt with in the course of a farm walk, the immediate impression gained by the farmers in a farm circuit seems to be more intense. This does not mean, however, that farm circuits are in any way superior to farm walks in the dissemination of information. They can never reach the same numbers, dealing as they do with only six people where the farm walk deals with hundreds, and it is not suggested that they should supersede the farm walk as an advisory system. The latter still remains the speediest method of spreading an interest in technical development, and the farm circuit, whilst being

an excellent small innovation, should only be used to supplement the wider effect of the farm walk.

Work Study

A further topical subject which has been encouraged by the Local Productivity Committees is that of work study, and already two one-day courses and a three-day exercise have been run, and a further course is likely in the near future. The N.A.A.S. has co-operated in the arrangements for, and in running, these events.

As a result of attendance at N.A.A.S. courses, a number of Advisory Officers have carried out work study exercises on farms and holdings in the county. The subjects so far dealt with are silage-making, silage feeding, tomato packing and grading and the milking routine in modern milking parlours. The work on silage has been organized so as to include most of the normal systems of silage-making and has proved both a valuable experience for the Advisers and of real use to the farmers concerned in showing how the system can be improved or simplified in certain cases.

This work is still in its infancy and although it takes up a fair amount of time, useful information is being collected which can help to form the basis for work study standards to be used in much the same way as the standards in the Farm Management Handbook. Undoubtedly much can be done by District Officers and their specialist colleagues, and it is desirable that officers of the Service should be familiar with this new technique. Having carried out work of this kind, an officer is much better able to use the information collected and to interpret information from standards produced by others.

Would readers please note that the current Volume of the REVIEW, *Vol. IX, will comprise SIX issues: Nos.* 35, 36, 37, 38, 39 *and* 40.

E6477 Wt.30 K27 3/58 Gp.8 F. & C. Ltd.

MINISTRY OF AGRICULTURE, FISHERIES AND FOOD

Plant Pathology

A quarterly publication presenting original contributions on plant diseases, plant pests, rodent and bird damage, nutritional and physiological disorders of interest to the mycologist, entomologist, helminthologist, soil or nutrition chemist, plant physiologist and meteorologist.

Single Copies 5*s.* (5*s.* 4*d. by post*)
Yearly Subscription 21*s.* 4*d.* (*including postage*)

For new readers . . .
back numbers are available
from

HER MAJESTY'S STATIONERY OFFICE

at the addresses on the reverse of the title page
or through any bookseller

COLONIAL

PLANT AND ANIMAL

PRODUCTS

A quarterly publication of the Colonial Products Laboratory dealing with the cultivation, preparation and utilisation of plant and animal products with special reference to those of the British Colonial Territories. It contains articles on the above subjects ; reports of investigations carried out by the Laboratory ; book reviews and bibliography of recent publications and articles on the above products.

Price 6*s.* *By post* 6*s.* 6*d.*
Annual subscription 26*s. including postage.*

Obtainable from

HER MAJESTY'S STATIONERY OFFICE

at the addresses on the reverse of the title page
or through any bookseller

S.O. Code No. 72-20-58-1